HISTORY OF THE WATERWAYS EXPERIMENT STATION

1 June 1968

J. B. Tiffany

Technical Director

Editor

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WES Monthly Staff Conference, 21 March 1968

Left to right: COL John R. Oswalt, Jr., Director; F. R. Brown, Assistant Technical Director; W. J. Turnbull, Chief, Soils Division; G. L. Arbuthnot, Jr., Chief, Nuclear Weapons Effects Division; C. B. Patterson, Chief, Technical Services Division; J. M. McCaskill, Chief, Reproduction and Reports Branch; J. S. Taylor, Jr., Chief, Office of Administrative Services; J. W. Pettigrew, Chief, Safety Office; E. P. Fortson, Jr., Chief, Hydraulics Division; J. J. Kirschenbaum, Jr., Chief, Supply and Procurement Office; L. C. Marsalis, Jr., Personnel Officer; C. H. Lefeve, Chief, Technical Liaison Office; C. G. Evans, Comptroller; J. G. Schaffer, Chief, Construction Services Division; Bryant Mather, Chief, Concrete Division; W. G. Shockley, Chief, Mobility and Environmental Division; Mrs. Jane Cotton, Administrative Assistant; LTC Levi A. Brown, Deputy Director; J. B. Tiffany, Technical Director.

Foreword

The History of the Waterways Experiment Station was prepared in accordance with ER 870-1-1, dated 20 July 1966, which established the general responsibilities, policies, and procedures governing installation historical activities.

The Director, COL John R. Oswalt, Jr., assigned the task of editor to Mr. J. B. Tiffany, Technical Director, with any assistance needed to be provided by other staff members. The main text, as well as the outline for the entire History, was prepared by Mr. Tiffany with the assistance of the following individuals who prepared one or more paragraphs pertaining to subjects in their particular fields of interest: Mrs. Jane C. Cotton, Administrative Assistant; Mr. Fred R. Brown, Chief, Office of Technical Programs and Plans; Mr. W. J. Turnbull, Chief, Soils Division; Mr. C. G. Evans, Comptroller; Mr. William F. Lauderdale, Chief, Personnel Management Assistance Branch; and Mr. C. H. Lefeve and Mrs. Dale Bean of the Technical Liaison Office. The Appendixes were prepared by former Directors of the Experiment Station and by Chiefs of Divisions, Branches, and Offices, with some assistance from their respective staffs. The organization charts, maps, and photographs were reproduced by employees of the Reproduction and Reports Branch under the supervision of Mr. J. M. McCaskill, former Chief of the Branch.

The History has been prepared in loose-leaf form so that it can be easily supplemented and brought up to date in the future.

Special acknowledgment is due Mrs. Jane C. Cotton, Assistant Editor, for searching out facts, names, and dates; for composing several paragraphs of the text; and for assisting in editing the entire document.

This History is dedicated to those who made it possible--the present and former civilian and military employees whose services have contributed to the success of the Waterways Experiment Station.

JOSEPH B. TIFFANY
Technical Director
Editor

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HISTORY OF THE WATERWAYS EXPERIMENT STATION

1 June 1968

Present Scope of Waterways Experiment Station Activities

1. The Waterways Experiment Station (WES) has grown, from 1929 to the present (1968), from a small, modest hydraulic laboratory with a lieutenant as Director and perhaps a dozen Civil Service employees to become the largest and most diverse engineering laboratory of the Corps of Engineers engaged in research in such engineering fields as hydraulics, soils and foundations, concrete, flexible pavements, nuclear weapons effects, mobility, environmental effects, geology, terrain analysis, expedient surfacing, soil dynamics, and rock mechanics. The organization now has more than 1300 Civil Service employees, as well as a military complement of a colonel (Director), a lieutenant colonel (Deputy Director), 10 junior officers, and 32 Army enlisted personnel. The activity has grown from a dollar work volume of $50,000 for the first year of its operation to an $18.6 million in-house program in Fiscal Year 1968. The organization has published hundreds of technical reports and miscellaneous papers which have been distributed all over the world, and it is visited annually by more than 20,000 official visitors and tourists.

Political Background of WES Origin

2. The origin of WES is extremely interesting in that it was fraught with political implications. Mr. John R. Freeman, a prominent and successful engineer in the structural field, during a visit to Europe in the middle 1920's, became so greatly impressed by the hydraulic laboratories of the Technical Universities, particularly in Germany, that he took it upon himself to establish a fellowship for study in that field and to begin a campaign for acceptance of the principle in the United States. To this end, he financed the translation of a book from German on the subject of Hydraulic Laboratory Practice and then set out to convince governmental officials that there should be a hydraulic laboratory in the national structure. If the Corps of Engineers would sponsor it, well and good; if not, it should be elsewhere. Mr. Freeman's proposal to the Chief of Engineers, U. S. Army, that a hydraulic laboratory be established by the Corps received an unencouraging response. Thereupon, he turned his efforts to the establishment of a national hydraulic laboratory in the Bureau of Standards. Upon hearing of this, the Office, Chief of Engineers (OCE), decided that it would be better to have control of its own hydraulic determinations than to rely on a laboratory of another Federal agency. Reluctantly, therefore--and grudgingly at first--it accepted the idea and set about developing plans for establishing a laboratory. The matter of whether to establish a hydraulic laboratory within the Corps or the Bureau was debated by several

committees of Congress, and the decision was finally made--upon what would be regarded now as peculiar reasoning and logic--to establish a laboratory within the Corps. With the battle won, it was decided not to oppose a similar institution in the Bureau, because President Herbert Hoover had been a principal proponent for a laboratory in the Bureau of Standards when he was Secretary of Commerce. To avoid disturbing the waters, it appeared best in fact not to build a "laboratory" at all--but to call it an experiment station. Even the word "hydraulic" was supplanted by "waterways." A complete account of this background of the WES origin is told by BG Herbert D. Vogel, first Director of WES, in Appendix I, written especially for this history in 1968.

Authorization for Establishment of WES

3. The 1928 Flood Control Act, setting up responsibility for flood control on the lower Mississippi River, contains a paragraph that authorized the Chief of Engineers to establish a hydraulic laboratory for purposes of studying details of the flood-control plan for the lower Mississippi River. By letter of 18 June 1929, the Chief of Engineers directed the President, Mississippi River Commission (MRC), to establish a hydraulic laboratory for these purposes; originally, it was to be established in West Memphis, Arkansas, but later before any construction actually started, it was decided to change the location to Vicksburg, Mississippi. This letter from OCE is now officially cited as the authority for the establishment of WES. Further details of the authorization for WES are also contained in Appendix I.

Operation Under President, MRC (1929-49)

4. As stated in the preceding paragraph, the WES was originally authorized to be established under the President, MRC. The careful distinction was subsequently made by successive Presidents of MRC and Directors of WES that the Director operate under the supervision of the President, MRC; however, the WES organization operated only administratively under the office of the President, MRC. The technical operations of WES were not usually subject to review by the MRC staff. This method of WES operation lasted from its establishment in 1929 until 10 August 1949.

Operation Under OCE (1949 to Present)

5. Almost from its inception, the WES began to undertake engineering projects (principally hydraulics) for districts and divisions other than those operating under the President, MRC, and Division Engineer, Lower Mississippi Valley Division (LMVD). By 1949, only a relatively small proportion of WES activities was actually being performed for the MRC/LMVD and its districts, whereas the majority of its

operations were for the OCE and other districts and divisions of the Corps. Recognizing this situation, OCE decided to remove WES from the administrative supervision of the President, MRC, and to set it up to report directly to OCE. This action was consummated by OCE General Order No. 9, dated 29 July 1949. Since that date, WES has operated directly under OCE, specifically under the direction of the Director of Civil Works of OCE, although projects are undertaken for other directorates of OCE as well as for Corps of Engineers districts and divisions and other agencies.

Organization of WES

6. The present organization of WES is shown in Appendix II. As will be noted thereon, the organization consists basically of an executive office, an advisory and administrative staff, and a technical staff composed of five technical divisions (Hydraulics, Soils, Concrete, Nuclear Weapons Effects, and Mobility and Environmental), and two support divisions (Technical Services and Construction Services). The inclusion of this appendix serves not only to illustrate the organization, but also to indicate for this History the names of key personnel responsible for operation of WES at the current writing.

7. A selected group, from those still available, of past organization charts is attached as Appendix III. The purpose of including these charts is to illustrate the gradual growth of WES, the gradual changes in organization, the influence of successive directors of WES, and the names of key personnel who were responsible for the development of WES to what it is today.

Physical Layout

8. The WES originally occupied an area of about 147 acres located in rolling land about five miles southeast of what were then the city limits of Vicksburg, Mississippi. Subsequently, additional land has been procured for the Vicksburg reservation, which now includes about 595 acres. In 1942, as a part of the establishment of the Mississippi Basin Model (MBM), and its first construction by German prisoners of war (see Appendixes V and XI), about 800 acres of land were procured near Clinton, Mississippi, about seven miles southwest of Jackson, Mississippi. The Concrete Division was established on this second reservation (see Appendix VII) in 1946.

9. Aside from the MBM and the Concrete Division, all operations of the WES are contained at the Vicksburg Installation. It should be noted that a new concrete Division laboratory and office building is being constructed at the Vicksburg Installation and that the Concrete Division will be moved to Vicksburg in calendar year 1969. Moreover, testing operations on the MBM will probably be phased out in

Fiscal Year 1969 or 1970, after which operations of WES, except for field tests, will be confined to the Vicksburg Installation.

Fiscal Operation

10. During the early years of its history, costs of the WES were financed from funds available to the President, MRC. With the commencement of engineering research projects for other districts and divisions of the Corps of Engineers, a reimbursable method of operation was established whereby each sponsoring office or agency paid the complete cost of work performed at WES. Some of the physical plant at WES was paid for from MRC funds during the early history of the Station. In later years, however, almost all physical facilities have been provided by the Corps of Engineers Revolving Fund, with the amortization of these costs charged against projects using the facilities.

11. The WES has never operated under any appropriation from Congress, except for the MBM whose funding is a line item in the Civil Works Appropriation Bill. All other operations are financed on a reimbursable basis, with the sponsoring office paying the complete cost, including overhead, of any research or testing performed at WES. Appendix XVII contains details of the fiscal operation of WES.

Present Book-of-Work and Sponsors Thereof

12. The following table presents the book-of-work for the current fiscal year, identified by sponsors thereof:

Sponsor (Department/Agency)	Program
Department of Defense	
Army	
Corps of Engineers	
Office, Chief of Engineers	$ 3,678,000
Other Corps of Engineers Offices	5,461,000
Army Materiel Command	5,767,000 (1)
Other Army	953,000
Air Force	1,430,000 (2)
Advanced Research Projects Agency	88,000
Defense Atomic Support Agency	2,933,000
Defense Communication Agency	246,000
Defense Intelligence Agency	152,000
Navy	123,000
Office of Civil Defense	101,000
Atomic Energy Commission	511,000
National Aeronautics and Space Administration	54,000

(Continued)

(1) Excludes special landing mat procurement (non-mission activities) for Mobility Equipment Command in the amount of $14.757 million.

(2) Excludes special landing mat procurement (non-mission activities) in the amount of $7.142 million.

Sponsor (Department/Agency)	Program
Other Non-Defense Agencies (Agriculture, Interior, TVA)	$ 236,000
Non-Government Agencies	24,000
Total	$21,757,000 (3,4)

(3) Excludes capital improvements to Revolving Fund facilities in the amount of $2.7 million.
(4) Includes contracts in the amount of $3 million.

Hydraulics Division

13. As indicated above, the WES was originally nothing more than a small hydraulic laboratory. From 1929 to 1939, the hydraulic work was undertaken by what were known as groups, subgroups, experiment sections, etc. The Hydraulics Division was first formally established in 1939 under the directorship of 1LT Paul W. Thompson, with Mr. Joseph B. Tiffany as Chief of the Division. The complete story of the history of the Hydraulics Division is contained in Appendix V.

Soils Division

14. The origin of the Soils Division was the establishment in 1932 of a small group whose purpose was principally to make grain-size analysis of samples of bed load and sediment taken from the Mississippi River. The Soils Division as such was also established in 1939 under the directorship of 1LT Paul W. Thompson. Mr. Spencer J. Buchanan was chief of soils activities from about 1933 to 1940, and became Chief of the Soils Division in 1939, as noted above. A complete history of the Soils Division is contained in Appendix VI.

Research Center

15. About 1936, the need became apparent for a soils research center, and Mr. Robert M. German was assigned to this activity, under the organization of the "Soils Experiment Section." In 1937, a similar need became apparent for a hydraulic research center, and a small group was formed for this purpose. Financing was originally from overhead funds or from funds assigned to WES by sponsoring offices. In 1940, the two groups (soils and hydraulics) were combined into what is still known as the Research Center, first under the supervision of LT Wright Hiatt and then under Mr. Samuel Shulits during the directorship of CPT Kenneth E. Fields. Relatively inactive during the war years, the Research Center was reorganized as a major technical unit in 1946 under the supervision of Mr. Charles B. Patterson during the directorship of COL Carroll T. Newton. For approximately the past twenty

years the Research Center and its central library have been financed from Engineering Studies funds supplied by the Office, Chief of Engineers, supplemented as necessary by charges to military accounts for services received. The complete history of the Research Center is contained in the description of the Technical Services Division in Appendix X.

Concrete Division

16. In 1946, OCE decided to centralize at WES almost all Civil Works engineering research of the Corps of Engineers. As a step in this direction, OCE ordered the transfer of the Central Concrete Laboratory of the North Atlantic Division, located at Mt. Vernon, New York, to the WES under the directorship of COL Carroll T. Newton. This move was actually consummated in 1946 with the construction of a new building at the Jackson Installation (see paragraph 8 above) and with the transfer of all of those of the old Central Concrete Laboratory staff who were willing to transfer from New York State to Mississippi. The first chief of the Concrete Division was Mr. Charles E. Wuerpel. The history of the Concrete Division, both before and after its transfer to WES, is contained in Appendix VII.

Mobility and Environmental Division

17. The Mobility and Environmental Division originated as part of the Soils Division. The Soils Division became so large and its projects so diverse in nature that this separate division was established in 1963 under the directorship of COL Alex G. Sutton, Jr. The history of the Mobility and Environmental Division is contained in Appendix IX.

Nuclear Weapons Effects Division

18. This activity had its origin as the Special Investigations Section of the Hydrodynamics Branch of the Hydraulics Division in 1951. This part of the organization was established upon request of the Armed Forces Special Weapons Project during the directorship of COL H. J. Skidmore.

19. In 1963, it being recognized that the Nuclear Weapons Effects projects had become very large, its personnel many, and its mission somewhat unrelated to the Hydraulics Division fields, a separate Nuclear Weapons Effects Division was established during the directorship of COL Alex G. Sutton, Jr. The history of this division is contained in Appendix VIII.

Technical Services Division

20. The Technical Services Division was formed in 1949, to include the

Research Center and its library and Reports Branch, the Instrumentation Branch, the Reproduction Branch, and the Training and Information Branch. Mr. J. B. Tiffany was assigned as the first Chief of the Technical Services Division in addition to his other duties as Special Assistant to the Director. About a year later, Mr. Tiffany was relieved of this dual assignment and Mr. Charles B. Patterson was assigned as Chief of the Technical Services Division. The history of this division is contained in Appendix X.

Construction Services Division

21. The Construction Services Division originated about 1930 with a small group of laborers and a construction foreman borrowed from the Vicksburg District for the purpose of constructing models. In 1937, three sections--Operations, Construction, and Mechanical--performed construction support services for the WES. In 1946, these sections were organized into the Operations Division under the directorship of COL Carroll T. Newton, and in 1951, this division was reorganized as the Construction Services Division. The complete history of this division is contained in Appendix XI.

Reproduction and Reports Branch

22. Reproduction and reports activities have been in progress since the beginning of WES. Mr. Francis B. Gautier was assigned as a photographer during the early 1930's; a drafting section was established during the early 1930's; plates for reports were reproduced by the blueprint or black line process during this period; and each project engineer was responsible for his own report, the earliest ones being simply letters to sponsoring offices signed by the Director. The first reproduction equipment was acquired in 1938 with the loan of a National Guard multilith machine, and reports for the first time were reproduced by the multilith process. In 1946, a Reports Branch was added to the Research Center organization, and a Reproduction Branch was established with drafting, photographic, and printing activities assigned. In 1949, the Reproduction Branch was transferred to the Technical Services Division, and soon thereafter it was reorganized as the Reproduction and Reports Branch to include the former Reports Branch which was transferred from the Research Center to the Reproduction and Reports Branch as a section. The complete history of the Reproduction and Reports Branch is contained in Appendix XV.

Administrative Activities

23. As stated in paragraph 4 above, administrative activities (Fiscal, Personnel, Office Service, Supply, etc.) were under the supervision of the Chief Administrative Assistant at MRC during the early years. During the 1930's and

early 1940's, much of this activity was gradually delegated directly to WES, and shortly after World War II all administrative affairs were handled entirely by WES, except that they were still under the supervision of the Chief Administrative Assistant of MRC until the transfer of WES to OCE in 1949. Mr. James H. Moore was the Chief Clerk almost from the beginning of the Station in 1929 until 1946. The history of administrative activities is covered more completely in Appendixes XIII through XIX.

Directors of WES

24. There have been fifteen directors of the WES thus far. A complete list of Directors, together with the dates of their terms of office, is shown below.

1LT Herbert D. Vogel	Oct 1929 - Aug 1934
1LT Francis H. Falkner (Deceased)	Aug 1934 - June 1937
CPT Paul W. Thompson	July 1937 - Sept 1939
CPT Kenneth E. Fields	Sept 1939 - Dec 1941
Mr. Gerard H. Matthes (Deceased)	May 1942 - Sept 1945
LTC Clement P. Lindner	Oct 1945 - Dec 1945
COL Carroll T. Newton	Jan 1946 - Dec 1946
COL John R. Hardin	Jan 1947 - Mar 1947
LTC Ralph D. King	July 1947 - July 1950
COL Herrol J. Skidmore	Aug 1950 - Aug 1952
COL Carroll H. Dunn	Sept 1952 - May 1955
COL Andrew P. Rollins, Jr.	June 1955 - July 1958
COL Edmund H. Lang	Aug 1958 - Aug 1961
COL Alex G. Sutton, Jr.	Aug 1961 - Dec 1964
COL John R. Oswalt, Jr.	Dec 1964 -

Comments of those of the former Directors who responded to a letter concerning this history are contained in Appendix IV, except that GEN Vogel's description of the origin of the WES is shown separately in Appendix I.

Assistant and/or Deputy Directors of WES

25. There have been eleven assistant and/or deputy directors of the Station. A list of those who have served in this capacity is shown below.

1LT Francis H. Falkner	1933 - July 1934
1LT Kenneth D. Nichols	1936
1LT Paul W. Thompson	Jan 1937 - June 1937
2LT Oliver G. Haywood, Jr.	1937 -
1LT Douglas C. Davis	1939 - 1940
1LT Wright Hiatt	1940
Mr. Joseph B. Tiffany, Exec Officer	1940 - 1 July 1943
CPT Joseph B. Tiffany, Exec Asst	1 July 1943 - 1 June 1945
Mr. Joseph B. Tiffany, Tech Exec Asst	1 July 1946 - 1 Dec 1949
Mr. Joseph B. Tiffany, Special Asst	1 Dec 1949 - 1 July 1951
MAJ Gordon L. C. Scott, Exec Officer	1 July 1950 - 1 Mar 1951
Mr. Joseph B. Tiffany, Asst Director	1 July 1951 - 1 Jan 1957
Mr. Joseph B. Tiffany, Tech Director	1 Jan 1957 -

LTC Marion I. Guest, Deputy Director	11 Nov 1963 - 13 Jan 1966
LTC Guy E. Jester, Special Asst	28 Aug 1965 - 13 Jan 1966
LTC Guy E. Jester, Deputy Director	14 Jan 1966 - 2 July 1967
LTC Levi A. Brown, Deputy Director	5 July 1967 -

Military Assistants

26. After military projects were assigned to WES, opportunities were created for younger officers to be assigned to the Station and to be associated with these projects. The first such project upon which younger officers were used was the airfield evaluations conducted during the period 1951-1957. This project extended into many foreign countries and the need for an officer to coordinate activities between the military and civilian teams, as well as to get the support of the military forces in the areas of duty, became evident. As the Station expanded in military projects, increased numbers of young officers were assigned. In many instances these young officers had completed academic work for the Ph. D. and completed their dissertations while simultaneously doing constructive work on a WES project. The assignments were usually from among regular Army officers; however, there were some instances of Reserve Officers being assigned because of their highly specialized qualifications in an area of interest to the Station. Ten of these young officers are presently assigned.

Technical Director

27. In the fall of 1940, CPT Kenneth E. Fields, Director, together with BG Max G. Tyler, President, MRC, determined that it would be advisable to set up a civilian organization to carry on the activities of WES in case the United States should get into World War II. At this time, the then Assistant Director, 1LT Wright Hiatt, was relieved and sent to Newfoundland for military construction of an air base. The then senior civilian engineer at WES was transferred to the Office of the President, MRC. Mr. Joseph B. Tiffany was thereupon assigned as Executive Officer by Memorandum of the Director dated 10 October 1940. Mr. Tiffany has served in this or similar capacity since that date to the present, except for one year (1945-46) when he was assigned temporarily to the President, MRC, as the Training Officer for the LMVD. Mr. Tiffany has served in this capacity under the titles of Executive Officer, Executive Assistant, Technical Executive Assistant, Special Assistant, Assistant Director, and now Technical Director.

Assistant Technical Director

28. On 14 Dec 1964, COL Alex G. Sutton, Jr., established the position of Assistant Technical Director to provide someone to assist the Technical Director

and to act in his absence. Mr. Fred R. Brown, who at the time was Chief of the Nuclear Weapons Effects Division, was assigned to this position and later given dual responsibilities as Chief of the Office of Technical Programs and Plans (Appendix XII).

Executive Assistant and Administrative Assistant

29. In 1946, the position of Executive Assistant was established by COL Carroll T. Newton, Director, and Mr. William L. Bache, Jr., was transferred from the MRC to WES to fill this position. Mr. Bache served in this capacity from 1946 until his retirement for disability in the fall of 1966 except for a period of military duty during the Korean War (1951-1953) and another two-year period (1958-1959) when he served as Comptroller for the newly established Pacific Ocean Division. Mr. C. G. Evans, then Fiscal Officer, now Comptroller, served as Executive Assistant during the first period of absence. The position remained vacant during the second period of absence.

30. In February 1967, the position of Administrative Assistant was established to fulfill a portion of the duties formerly held by Mr. Bache, as well as certain new duties. Mrs. Jane C. Cotton, who had served as Executive Secretary to the Director since 1951, was assigned to this position.

Impact of World War II

31. The impact of World War II on WES was tremendous. Most of the Civil Works activities of the Corps of Engineers were curtailed, or at least slowed down, and the work of WES took on an entirely different turn, with emphasis on war-oriented activities. Chief among the projects undertaken during the war were the study of the stability of artificial harbor breakwaters designed and constructed for the 1944 Normandy invasion, testing of airfield landing mats, studies concerned with mobility, and design of flexible airfield pavements for the Air Corps. Two important Civil Works activities were undertaken which are worthy of special note. First, a comprehensive series of potamology investigations was undertaken and carried through by CPT Joseph F. Friedkin, under the immediate supervision of GEN Tyler; the results of this investigation led to the authorization of the 1944 Mississippi River Flood Control Project, including the 12-ft navigation channel and the bank stabilization program on which the MRC and its districts have been engaged ever since. Second was a very comprehensive geological investigation of the Lower Mississippi Valley, conducted by Dr. Harold N. Fisk of Louisiana State University. The results of this geologic investigation have guided the engineering work in the Lower Mississippi Valley ever since.

32. Obviously, a principal impact of World War II was on personnel. During

the period that Veteran's Preference was allowed for service in the Armed Forces there were 631 employees (including mostly men, but a few women employees as well) who were in service at some time during this period. This left a tremendous gap in the personnel strength of WES. This gap was largely filled during World War II by the employment of women as technicians, although the key positions were still held by men employees who were not called into service. WES could not have survived World War II as an organization without the contribution of the women, many of whom were the wives of service men. A complete list of the personnel in the service during World War II is contained in Appendix XX.

Reorganization and Reemployment After World War II

33. During the period November 1945 through April 1946 over 100 veterans returned to the Station and exercised their reemployment rights. These veterans were assimilated into the work force with the recognition of their rights to positions they held at the time of departure and to positions to which they would have progressed had they remained at the Station. It became evident that a reorganization was needed to give full effect to the expanded technical work of the Station and to provide positions for those returning veterans whose former positions were no longer discernible in the organization.

34. In June 1945, CPT Joseph B. Tiffany, Executive Assistant, was transferred to the Mississippi River Commission for a special assignment with the understanding that he would return to the Station upon completion of the special assignment. He returned to WES in a civilian capacity in June 1946 and assumed his former position of Executive Assistant. In the meantime, the Waterways Division and the Hydrodynamics Division were remerged and re-formed into the Hydraulics Division. Mr. E. P. Fortson, a returned veteran, was assigned as Chief of the Hydraulics Division. The instrumentation work that was formerly under the Hydraulics Division and the Reproduction Division functions were transferred to the newly organized Technical Services Division, which was headed by Mr. Tiffany as an additional responsibility. The Embankment, Foundation, and Pavement Division was renamed the Soils Division, and Mr. W. J. Turnbull who had headed this organization during the war years continued as Chief of the Soils Division. The Geology Division was redesignated as the Geology Branch and was placed under the Soils Division. The Research Center was reactivated and reorganized by Mr. C. B. Patterson, former Chief of one of the five Hydraulic Experiment Sections, upon his return from the service. The Laboratory Services Division experienced reorganization changes during the latter part of World War II. Mr. George W. Vinzant was transferred to WES and made Chief of the Operations Division. This division absorbed all functions performed by the Laboratory Services Division, the Security force, and the Supply function. Mr. Charles R. Warndof, who left the Station as Chief of Laboratory Services, returned from

military service and was given a branch chief assignment in the Operations Division. The large construction program under way at Clinton on the MBM was headed by Mr. Alton G. Davis under the general supervision of Mr. Vinzant. To keep pace with the expanded functions of the Station, the Administrative Advisory Staff was identified and responsibilities separated in a chain of command headed by Mr. W. L. Bache, Jr., Chief Administrative Assistant, who transferred from the Mississippi River Commission.

Impact of Korean War

35. The impact of the Korean War was not nearly so drastic as that during World War II, but it was still severe. In the first place, the Civil Works activities of the Corps of Engineers took a tremendous drop, which was compensated for in about a year by a rapid rise in military research. A group of over 100 civilian employees was lost by the calling into duty of the WES-sponsored 434th Engineer Construction Battalion, commanded by LTC Eugene P. Fortson, Chief of the Hydraulics Division. In addition to the 434th, a number of personnel losses occurred as the result of the calling into duty of the National Guard 31st Division; additionally, quite a number of individuals were called into duty. A fairly complete list of personnel called into service during the Korean War is contained in Appendix XXI, along with those who have served in the Vietnam War.

Impact of Vietnam War

36. Unlike World War II and the Korean War, the Vietnam War has not as yet resulted in any slowing down of either Civil Works or military research activities. To the contrary, a considerable number of Vietnam-oriented projects have been assigned to.WES, all on a crash basis. Included are such projects as the following: a model study of a harbor at "Site X" in Vietnam; the detection, location, and destruction of Viet Cong tunnels; the geographic location of construction materials in the Mekong Delta; the design of prefabricated protective shelters and fighting bunkers; the design and procurement of several million square feet of steel and aluminum landing mat; the design of membranes for airfield and road construction, dust control problems, etc.

37. No Reserve or National Guard units containing WES employees have as yet been called into duty. A list of those employees who have been called as individuals is included in Appendix XXI, along with those who served in the Korean War. A total of 238 WES employees have served in the Armed Forces during the Korean and Vietnam Wars.

Civil Versus Military Work Loads

38. Until World War II, all work at WES consisted of projects related to the Civil Works activities of the Corps of Engineers. As stated above, during World War II a number of military projects were assigned.

39. Further as cited above, there was a sharp increase in Military Construction work during the Korean War from 1950 to 1952, and the military work load has increased steadily ever since. As of this writing, military work accounts for approximately 65 percent of the work load of WES, with Civil Works accounting for the remaining 35 percent.

Mississippi Basin Model

40. The Mississippi Basin model, the largest hydraulic model in the world, is located at the Jackson Installation of the WES about nine miles southwest of Jackson, Mississippi. It is a fixed-bed model of the Mississippi River and its tributaries with the floodplains and stream channels accurately molded in concrete to a horizontal scale of 1:2000 and a vertical scale of 1:100. The model itself covers 210 acres and reproduces 1,250,000 square miles of the Mississippi River Basin (41 percent) of the land area of the continental United States). This flood-control model was designed and constructed so that it can be operated either as a unit for basin-wide problems or in sections to aid in the solution of local problems. It is operated entirely by automatic instruments that were specially designed and manufactured for use on it. A complete history of the model is contained in the description of the Hydraulics Division in Appendix V.

Potamology Investigations

41. The Station conducted a series of potamology investigations for the MRC and its districts during the period 1947-1952. The hydraulic phase was instituted in 1947 and continued actively through 1951 at an average rate of about $280,000 per year for the four-year period. Active investigational work was curtailed in 1951, but was resumed in the latter part of FY 1957. The soils phase was initiated in 1948 and was continued for four years at a rate of activity of about $50,000 per year. Subsequent to FY 1952, funds were reduced to about $1500 per year and the study limited to a study of the verification of an empirical method for determining slope stability and the preparation of a review of soil studies, which was accomplished by Dr. M. J. Hvorslev. The soils studies were also resumed in the latter part of FY 1957. These investigations are discussed in more detail in Appendixes V and VI.

Administration Building Fire

42. On 3 October 1960, the newly constructed (1953) wing of the main administration building was burned to the ground. Destroyed completely were the executive offices, most of the administrative offices, and all elements of the Technical Services Division except the Instrumentation Branch. The complete story of this fire is told in Appendix XXII. The rebuilding and restocking of the library is described in Appendix X.

43. Steps were taken before the fire was extinguished to make plans for a new headquarters building, and for the temporary housing of burned-out units until the new building could be completed. The new headquarters building was completed and occupied in June 1963. Other rehabilitation steps resulting from the fire are described in the appendixes describing the affected units of the organization.

Graduate Study Program

44. As early as 1957 the need for advanced education to enhance the engineering and scientific capabilities of WES was readily apparent. On the basis of this identified need, the WES constructively pursued the problem.

45. The WES plan for advanced education was, in the early months of 1963, submitted to OCE for approval, and initially was nothing more than a documented request for permission to send John Guy Jackson back to college for one full year to pursue advanced study toward his Ph. D. This request was approved and more or less set the stage for a continuing program, because in the latter part of 1963 OCE formally announced its program for advanced education. Under this program WES first was authorized to send two employees each year. In 1966, this authorization was increased to four. Six WES employees have completed advanced education under this program. There are presently four in school and four more have been approved to begin school this fall. The Department of the Army implemented a similar program in 1966 also, and as a result WES was authorized to send three additional employees to graduate school. Listed below are names of program participants, their organizations, and schools attended.

Completed or in Progress

John G. Jackson*	Soils Division	University of Michigan, 1964
Thomas E. Kennedy	NWED	Florida State University, 1965
Gerald W. Turnage	M&E Division	Florida State University, 1965
Don C. Banks*	Soils Division	University of Illinois, 1966
James L. Ferguson	Technical Services Division	University of Wisconsin, 1966
M. Burton Boyd	Hydraulics Division	Colorado State University, 1967
James E. McDonald**	Concrete Division	Mississippi State University, 1967
Jerry R. Lundien**	M&E Division	University of Kansas, 1967

* Study above master's level.
** Study under D/A program.

	Completed or in Progress	
Jim W. Hall, Jr.**	Soils Division	Texas A&M, 1967
Don R. Denton*	NWED	Duke University - Withdrew
Paul F. Hadala*	Soils Division	University of Illinois
Billy R. Sullivan**	Concrete Division	University of Texas
Newell R. Murphy	M&E Division	University of Alabama
James L. Drake*	NWED	Michigan State University
William E. Strohm*,**	Soils Division	University of California
Glen A. Pickering**	Hydraulics Division	Purdue University
Frank A. Herrmann*	Hydraulics Division	Delft Technological University
	Planned Attendance (1968-69)	
Ellis B. Pickett	Hydraulics Division	Vanderbilt University
George C. Hoff	Concrete Division	University of Illinois
Allen S. Lessem	M&E Division	Mississippi State University
Jesse L. Kirkland	NWED	Mississippi State University

* Study above master's level.
** Study under D/A program.

Vicksburg Graduate Center

46. Negotiations began as early as 1957 with Mississippi State University (MSU) and in March 1958, the Board of Trustees of State Institutions of Higher Learning approved MSU's recommendation to establish the Vicksburg Center for Graduate Study. The Center did not, however, immediately get under way. Many problems developed to block the establishment of the Center and it appeared that a graduate program with MSU was doomed.

47. In 1964, WES contacted Bradley University of Peoria, Illinois, to determine the extent of interest it might have in regard to establishing a resident center at WES. As it turned out, Bradley was very much interested, and by January 1965 planning had reached the point where policy governing operation was being formulated, schedules of courses were discussed, and WES employees were screened as prospective instructors.

48. This chain of events aroused concern among MSU officials who took immediate action to remedy the situations which prohibited their establishing a resident center at WES. Meanwhile, Bradley withdrew its offer. Final plans of operation were worked out with MSU and the first classes were scheduled to begin with the Fall Semester of 1965. The Vicksburg Center for Graduate Study opened with two courses--"Soil Mechanics: Embankment and Bearing Capacity" and "Indeterminate Structures I." The total enrollment was 25 students. Since this time 15 additional courses have been offered to an average semester enrollment of 16 in each class. Including the 65 students enrolled in the four courses presently under way, a total of 332 students have benefited from this program.

Courses Completed and/or in Progress Course Title	Semester
Soil Mechanics: Embankment and Bearing Capacity Indeterminate Structures I	Fall 1965
Soil Mechanics: Seepage Open Channel Hydraulics	Spring 1966
Applied Elasticity	Summer 1966
Soil Mechanics: Foundations Differential Equations	Fall 1966
Applied Mathematics I Hydraulic Structures Theory of Plasticity Soil Engineering for Transportation Facilities (Special Topics in Civil Engineering)	Spring 1967
Vibrations Inviscid Theory	Summer 1967
Theory of Continuous Media Soil Mechanics: Embankment and Bearing Capacity Waterways Applied Mathematics III Differential Equations	Fall 1967

Enlisted Personnel Program

49. Before the Army created the Scientific and Engineering (S&E) Program, college graduates in engineering and science were drafted into military service and given troop assignments that did not help their technical development and that represented a loss or misuse of talent in technical fields wherein shortage of college-trained manpower existed. College graduates qualifying for the Army S&E Program are now assigned after basic training to Army installations that can use their academic training on military projects. The WES is primarily interested in the Engineering, Mathematical, and Physical Sciences Assistants under this program, and since July 1954 a total of 159 enlisted men have been assigned. Currently, there are 32 S&E assistants at WES. Of the 159 assigned, 25 accepted employment with WES upon discharge from the service and 17 of these are currently employed. A key engineer, presently Chief of the Engineering Research Branch, Nuclear Weapons Effects Division, Mr. William J. Flathau, was one of the first engineers assigned to WES under this program in July 1954.

Silver Anniversary

50. The Silver Anniversary Celebration of the WES was held during 18-20 June 1954 while COL C. H. Dunn was Director. The celebration consisted of open house at the Vicksburg Installation from 2:00 until 9:00 p.m., on Friday, 18 June, and from

2:00 to 5:00 p.m., on Sunday, 20 June. Open house at the Jackson Installation was from 2:00 to 5:00 p.m., on Saturday and Sunday, 19 and 20 June. During these open house periods, some 19 exhibits and demonstrations were available for viewing throughout the Vicksburg Installation. At the Jackson Installation the open house consisted of inspections of operations and equipment of the Concrete Division and Mississippi Basin model. Several sound motion picture films depicting operations of the WES were shown continuously at various locations at both installations. The Vicksburg Chamber of Commerce sponsored a special edition in the Vicksburg Evening Post. A special ceremony was held at 8:00 p.m., on 18 June, which included an address by the then Chief of Engineers, MG Samuel D. Sturgis, Jr., and the introduction of former WES Directors who were present for the celebration. It was estimated that 3000 persons visited the Vicksburg Installation on 18-20 June, including approximately 1400 for the night ceremony on 18 June. About 1200 visited the Jackson Installation on the afternoons of 19 and 20 June.

Technical Society Participation

51. WES personnel are extremely active in many professional societies on a local, state, regional, national, and international level. Membership is held chiefly in those organizations that relate to the discipline in which the incumbent is working. For example, geologists are active in the Geological Society of America, engineers in the American Society of Civil Engineers, materials experts in the American Concrete Institute and American Society for Testing and Materials, etc. Since engineers predominate at WES, most activity is centered in engineering organizations and in particular the American Society of Civil Engineers. On the national level, Messrs. Turnbull, Johnson, and Shockley have served as Chairman of the Executive Committee of the Soil Mechanics and Foundations Division, while Messrs. Tiffany, Fortson, and Brown have served as Chairman of the Executive Committee of the Hydraulics Division; on a regional and local level, WES employees have served as officers and members of the board of direction. Of the 217 engineers at WES, 60 percent are registered professional engineers in one or more states. Mr. W. J. Turnbull has served as President of the Mississippi Society of Professional Engineers and is currently serving on the State Board for Registration of Engineers. Mr. Bryant Mather has served as President of the American Concrete Institute. Personnel of WES are active in such professional groups as the Highway Research Board, the American Society for Testing and Materials, American Society of Agricultural Engineers, American Association for the Advancement of Science, Society of American Military Engineers, National Science Foundation, American Institute of Professional Geologists, American Association of Petroleum Geologists, National Secretaries Association, and others. WES employees are also active in international professional societies such as the International Congress on Large

Dams, International Association for Hydraulic Research, Permanent International Navigation Congress, International Society for Terrain-Vehicle Systems, and International Society for Soil Mechanics and Foundation Engineering; Mr. Turnbull is currently serving as Vice-President of North America for the latter organization.

Awards

52. A number of WES employees have received awards of distinction conferred by professional and technical societies, Department of Defense, Department of Army, etc., above the local level. Those receiving such awards include:

	Award	Date
Executive Office		
W. L. Bache, Jr.	Meritorious Civilian Service Award	1966
Office of Technical Programs and Plans		
Fred R. Brown	War Department, Armed Services Forces, Commendation for Meritorious Civilian Service	1947
	Man of the Year Award, Vicksburg Junior Chamber of Commerce	1967
Reproduction and Reports Branch		
Aubrey W. Stephens, Jr.	CE Meritorious Civilian Service Award for Bravery	1966
Hydraulics Division		
Marden B. Boyd	ASCE Karl Emil Hilgard Hydraulic Prize	1965
Frank B. Campbell	Meritorious Civilian Service Award	1967
George B. Fenwick	Meritorious Civilian Service Award	1966
Garbis H. Keulegan	U. S. Department of Commerce Exceptional Service (Gold Medal Award) Award for Outstanding Service	1960
Soils Division		
M. J. Hvorslev	Research Prize, ASCE	1957
	Terzaghi Award, ASCE	1965
	Certificate of Achievement, Department of Army	1965
	Corresponding Member, Danish Academy of Technical Sciences	1965
	Honorary Member, Danish Society of Soil Mechanics and Foundation Engineering	1966
C. R. Kolb	Best Paper Award, Society of Economic Paleontologists and Mineralogists	1954
	Best Paper Award, Gulf Coast Association of Geologic Societies	1966

	Award	Date
Soils Division (Continued)		
C. R. Kolb	Department of Army Official Commendation, USA Arctic Test Center	1964
W. J. Turnbull	Exceptional Civilian Service Award, War Department	1946
	Distinguished Service Award, University of Nebraska	1949
	Honorary Doctor of Engineering Degree, University of Nebraska	1957
	Norman Medal, ASCE	1959
	Department of Army Exceptional Civilian Service Award	1964
	Department of Defense Distinguished Civilian Service Award	1965
	Commander's Award, U. S. Intercontinental Ballistic Missile Program, Ballistic Systems Division	1965
	Award of Fellow Member, International Society for Terrain-Vehicle Systems, Inc.	1966
	Engineer of Year Award, Mississippi Society of Professional Engineers	1966
Concrete Division		
Alan D. Buck	Secretary of Army Research and Study Fellowship	1963-64
	ACI Wason Medal for Research	1968
Rose C. Harrell	Department of Army Decoration for Meritorious Civilian Service	1966
Thomas B. Kennedy	ACI Wason Medal for Research	1954
	Department of Army Decoration for Meritorious Civilian Service	1965
	ASTM Award of Merit	1967
Bryant Mather	ASTM Award of Merit	1959
	Sanford E. Thompson Award	1961
	Department of Army Decoration for Meritorious Civilian Service	1965
	Roy W. Crum Distinguished Service Award, Highway Research Board	1966
Katharine Mather	Sanford E. Thompson Award	1953
	ACI Wason Medal for Research	1954
	Department of Army Decoration for Exceptional Civilian Service	1962
	Department of Defense Distinguished Civilian Service Award	1963
	Civil Service Commission Federal Woman's Award	1963
Leonard Pepper	Sanford E. Thompson Award	1961
James M. Polatty	Silver Beaver Award, Boy Scouts of America	1968
Kenneth L. Saucier	Department of Army Decoration for Meritorious Civilian Service	1965

	Award	Date
Concrete Division (Continued)		
William O. Tynes	Department of Army Decoration for Meritorious Civilian Service	1965
Charles E. Wuerpel	ACI Wason Medal for Research	1946
Nuclear Weapons Effects Division		
G. E. Albritton	United States Army Science Conference Certificate of Outstanding Achievement Award	1966
G. L. Arbuthnot, Jr.	Department of Army Commendation Medal	1967
J. T. Ballard	OCD grant to attend school	1966
W. J. Flathau	Young Engineer of the Year, MSPE	1963
T. E. Kennedy	United States Army Science Conference Certificate of Outstanding Achievement Award	1966
J. N. Strange	United States Army Science Conference Certificate of Outstanding Achievement Award	1962
R. E. Walker	United States Army Science Conference Certificate of Outstanding Achievement Award	1966
Mobility and Environmental Division		
J. G. Collins	Department of Army Commendation for designing a novel device for indicating maximum and minimum groundwater elevation	1963
D. R. Freitag	Secretary of Army Fellowship for graduate study	1961-62
J. L. McRae	Citation from American Society for Testing and Materials for technical paper	1959
B. G. Stinson	Department of Army Commendation for designing a novel device for indicating maximum and minimum groundwater elevation	1963
Construction Services Division		
G. W. Vinzant	Meritorious Civilian Service Award	1965

Corps Leaders Spawned by WES

53. Many former WES employees now hold or have held important positions in other Corps of Engineers installations. Worthy of particular mention are: J. M. Caldwell, Director, Coastal Engineering Research Center; W. K. Boyd, Technical Director, U. S. Army Cold Regions Research and Engineering Laboratory; George Howard (Retired), former Technical Director of Engineering Research and Development

Laboratory; J. H. Douma, Chief, Hydraulic Design Branch, and G. E. Bertram, Chief, Soils Branch, Directorate of Civil Works, Office, Chief of Engineers. Other former employees hold responsible positions in almost all district and division offices of the Corps.

Contributions of WES Employees to Local Community

54. In addition to WES employees contributing about $10,000,000 annually to the economic life of the community, they are involved in all aspects of community life and contribute much to its development. They are active in every church, serving from organist to chairmen of building committees; from Sunday School teachers and superintendents to deacons and elders; from chairmen of official boards to just plain participating church members. They are active in the youth work in both Vicksburg and Jackson and have served as scout troop leaders, Merit Badge examiners, and as scout council chairmen, and Mr. James M. Polatty has received the Silver Beaver Award in recognition of 35 years of active participation in scout activities; as Little League baseball organizers, coaches, and commissioners; as YMCA director, member, and coach of basketball and football; as program participants, organizers, and judges of science fairs and seminars; as PTA members and officials. In 1957, the PTA's of the five public schools plus the City Council in Vicksburg were headed by either employees or wives of employees of the Corps of Engineers. Five of the six positions were held by WES-affiliated personnel. Mr. J. B. Tiffany, Technical Director, was president of the City Council; Mr. F. R. Brown was president of the high school PTA; Mr. R. G. Ahlvin was president of the junior high school PTA; Mrs. A. A. Rula and Mrs. R. Y. Hudson, wives of engineers on the WES staff, served as presidents of two of the grammar school PTA's. The remaining public school PTA was presided over by the wife of an employee of the Vicksburg District. At the present time, Mr. Z. B. Fry is president of the high school PTA and Mr. William M. Pace is president of one of the grammar school PTA's. Every year WES employees serve in some capacity on Vicksburg, Jackson, and State PTA boards. Mr. Brown has served as Treasurer of the State PTA Board for several years. Employees also participate in Career Day sponsored by all civic organizations to advise high school students on certain vocations and college training necessary. In civic activities, employees have served as chairmen and members of the Vicksburg Harbor Commission, Beautification Commission, Planning Commission (Mr. Brown has been a member of this Commission for several years and is the present Chairman), and as members of Chamber of Commerce committees. Employees are active in all civic clubs, the Little Theatre, the VFW, American Legion, etc., and many have served on the board of directors and as president. WES employees (Messrs. Fortson, Skelton, Patterson, and others) are primarily responsible for the start and continuation of the city Rose Garden sponsored by the Men's Garden Club of Vicksburg. Strong leadership in

charitable drives such as the United Fund, Cancer, Heart, etc., is also provided. In Jackson, WES employees serve as members of the Civil War Round Table of Mississippi, the Mississippi Art Association, and the Mississippi Entomological Society. Mr. and Mrs. Bryant Mather are authors of "The Butterflies of Mississippi," Tulane Studies in Zoology (1958), and 36 other publications on Mississippi butterflies.

55. In summary, WES employees are so heavily involved in the community life of Vicksburg and Jackson that it is difficult to name any activity in which they are not participating.

Warren County Science Seminar

56. The Warren County Science Seminar (WCSS) is an extracurricular program for qualified high school students which is concerned with the round-table discussion of scientific or science-related topics. The Seminar is composed of outstanding high school students and a like number of adults from the surrounding professional community. The discussions are much advanced from the science available at the high school level and cover all phases of scientific thought in as much breadth and depth as the backgrounds of student and staff members will allow. This is a nonprofit organization with the professional people of the community contributing their time gratis. The WCSS was organized in April and May 1959, through a joint effort of the Student Scientific Guidance Committee (SSGC) of the WES and the Vocational Guidance Committee of the Vicksburg Branch, American Society of Civil Engineers (ASCE). The SSGC was authorized by WES Special Orders No. 7, dated 12 March 1959, to maintain relations with local high school officials and/or representatives of science classes and to offer guidance to staff members of the Science Seminar which was then being formed, since it is WES policy to participate in and support engineering and scientific activities in the secondary schools to the extent deemed reasonable and proper. The following WES employees were appointed by the Director to serve on the SSGC: W. J. Flathau, Chairman; W. G. Shockley, F. R. Brown, F. P. Hanes, J. N. Strange, C. H. Lefeve, Recorder; and Mrs. Dale Bean, Secretary. Most of those appointed were members of the ASCE Vocational Guidance Committee.

57. When the Seminar was established in Vicksburg, participation was limited to Cooper High School and to two parochial schools; however, a few years ago it was opened to all schools in the community and then became known as the Warren County Science Seminar. To participate in the WCSS, a student must have completed the 9th grade, have a special aptitude for the sciences, and pass a stiff entrance examination which is given each spring at the WES by WES employees. Although most staff members are WES employees, they also receive assistance from other governmental agencies, private industry, and medical profession, etc. Weekly sessions are conducted at the WES, which also makes available slide and movie projectors, library facilities, and tours of test facilities for the students. Dr. M. J. Hvorslev and

Messrs. Warren Grabau, R. G. Ahlvin, F. P. Hanes, and E. E. Addor have provided outstanding leadership for the Seminar. In addition to helping such high school students free of charge, the staff members have assisted in establishing Science Seminars in Laurel and Hattiesburg, Mississippi, and have just recently been asked to assist in establishing one at Yazoo City, Mississippi.

Consultants and Consulting Boards

58. Through the years the Station has been assisted in its research programs by outstanding authorities in the various fields of work. Some have served on an individual basis and others as members of a board or panel to analyze problems, formulate plans for work, review progress, evaluate results, etc. Those who are currently serving in a consulting capacity are listed below.

Concrete Division

Prof. Raymond E. Davis Dr. Roy W. Carlson Mr. Byram W. Steele Dr. Bruce E. Foster	Engineering Studies Program
Dr. Delbert E. Day Dr. Hans Gesund	Thermal stabilization of soils studies and various studies for the Structures Section

Hydraulics Division

Dr. Hunter Rouse Dr. Vito A. Vanoni Prof. Joe W. Johnson Dr. Arthur T. Ippen Dr. Garbis H. Keulegan	Hydraulic investigations under the Engineering Studies Program
Mr. George B. Fenwick	Channel stabilization and hydraulic engineering investigations
Dr. Donald W. Pritchard Mr. Clarence F. Wicker Mr. Francis F. Escoffier	Hydraulic engineering investigations
Mr. C. P. Lindner	Channel stabilization
Dr. Ray B. Krone	Radioisotopes Tracer Tests for Shoaling Materials

Nuclear Weapons Effects Division

Dr. Arnold Arons	Research on reflection of underwater shock waves
Dr. Melvin L. Baron	Shock wave propagation, particularly ground shock induced by nuclear devices and formulation of theoretical expressions for predicting the response of buried inclusions engulfed by shock waves
Dr. George B. Clark	Problems relating to underground explosions and protective facilities that are deeply buried or that are mined at considerable depth

Nuclear Weapons Effects Division (Continued)

Dr. Donald A. DaDeppo	Problems and programs in the general field of protective construction, concerning specifically the response of buried structures and individual structural elements to dynamic loading
Dr. Don U. Deere	Engineering properties of nuclear craters
Dr. Alfred J. Hendron, Jr.	Slope stability under earthquake loading
Dr. Charles B. Ivy	General field of protective construction, concerning specifically the response of buried structures and individual structural elements to dynamic loading
Dr. Joseph F. Libsch	Dynamic properties of materials, especially in the field of nuclear weapons effects
Dr. J. L. Merritt	Soil dynamics in construction, ground motion, and VAB rail beam studies
Dr. Grover L. Rogers	Dynamic response of above- and below-ground buried structures and with shock wave propagation
Dr. Mete A. Sozen	Consulting services on study of slab shear strength tests and AISI project on dynamic beam tests
Dr. Dudley H. Towne	Airblast, water shock, and acoustic approximations of low amplitude wave motions
Dr. David A. VanHorn	Reinforced concrete structures and models
Dr. Robert V. Whitman	Response of soils subjected to dynamic loadings, especially in field of nuclear weapons effects

Technical Services Division

Dr. Byron E. Short	Heat transfer and thermodynamic investigations and assisting Instrumentation Branch on redesign problems
Dr. James H. Tracey	Data reduction

Soils Division

Dr. Edward B. Cale	Erosion control studies
Dr. Ralph E. Fadum	Flexible pavement design
Dr. William H. Goetz	Bituminous mixtures and flexible pavement design
Dr. Lowell E. Gregg	Soil stabilization investigations
Dr. William J. Hall	Soil dynamics studies
Dr. Milton E. Harr	Flexible pavement problems
Dr. Lydik S. Jacobsen	Soil dynamics investigations and vibration studies
Dr. Nathan M. Newmark	Flexible pavement design and soil dynamics
Dr. Ralph B. Peck	Design criteria for drainpipe and flexible pavement design studies
Dr. Frank E. Richart, Jr.	Soil dynamics studies
Dr. Julian C. Smith	Soil stabilization studies
Dr. Thomas H. Thornburn	Soil stabilization studies
Dr. Reynold K. Watkins	Development of design criteria for drainpipe
Dr. Frank S. Gilmore	Flexible pavement problems

Soils Division (Continued)

Dr. Stanley D. Wilson	Soil dynamics studies
Dr. Kenneth B. Woods	Foundation and flexible pavement problems
Dr. R. C. Herschfeld	Soils engineering investigations
Dr. S. J. Poulos	Soils engineering investigations
Dr. J. M. Duncan	Finite element method of analysis for application to soil and rock mechanic problems
Mr. Thomas B. Goode	Problems relating to subsurface exploration and control of groundwater

Mobility and Environmental Division

The M&E Division currently has four consulting boards: Soil Moisture Predictions, Mobility Research, Remote Sensing, and Military Evaluation of Geographic Areas. Members of these boards consist of consultants and experts from other governmental agencies. The composition of the boards changes frequently. Those presently serving are as follows:

Dr. Arpad A. Warlam - Soil Moisture Prediction and Mobility Research
Dr. Robert N. Colwell - Remote Sensing
Dr. Laurence H. Lattman - Remote Sensing
Dr. August W. Kuchler - Military Evaluation of Geographic Areas
Dr. Norman W. Radforth - Military Evaluation of Geographic Areas
Dr. Pierre Dansereau - Military Evaluation of Geographic Areas
Dr. Howard T. Odum - Military Evaluation of Geographic Areas

Consulting Activities

59. The WES serves as a staff of consulting engineers and scientists, not only to the Corps of Engineers, but also to other elements of the Department of the Army, the Department of Defense, and many other governmental agencies as well. It has continuously in the field, in support of other agencies, both operating personnel and consultants, in connection with such problems as an earth slide, a foundation failure in a dam, a concrete failure in a navigation lock, river stabilization, the design of rubble-mound breakwaters, harbor wave action, soil mechanics, mobility, terrain analysis, the design of vehicles, cratering and ground shocks produced by explosions, and the telemetering of hydrologic data.

60. Staff members also serve as officers and members of important committees, i.e., Mr. Tiffany is Chairman of the Committee on Tidal Hydraulics and a member of the Committee on Channel Stabilization and the Potamology Board; Mr. Turnbull is a member of the Army Scientific Advisory Panel for Military Aspects of Geophysical Phenomena; and Mr. Eugene Woodman serves as representative on the Inter-Service

Committee on Technical Facilities, Southeast USA, replacing Mr. C. B. Patterson who was the original senior member of this Committee.

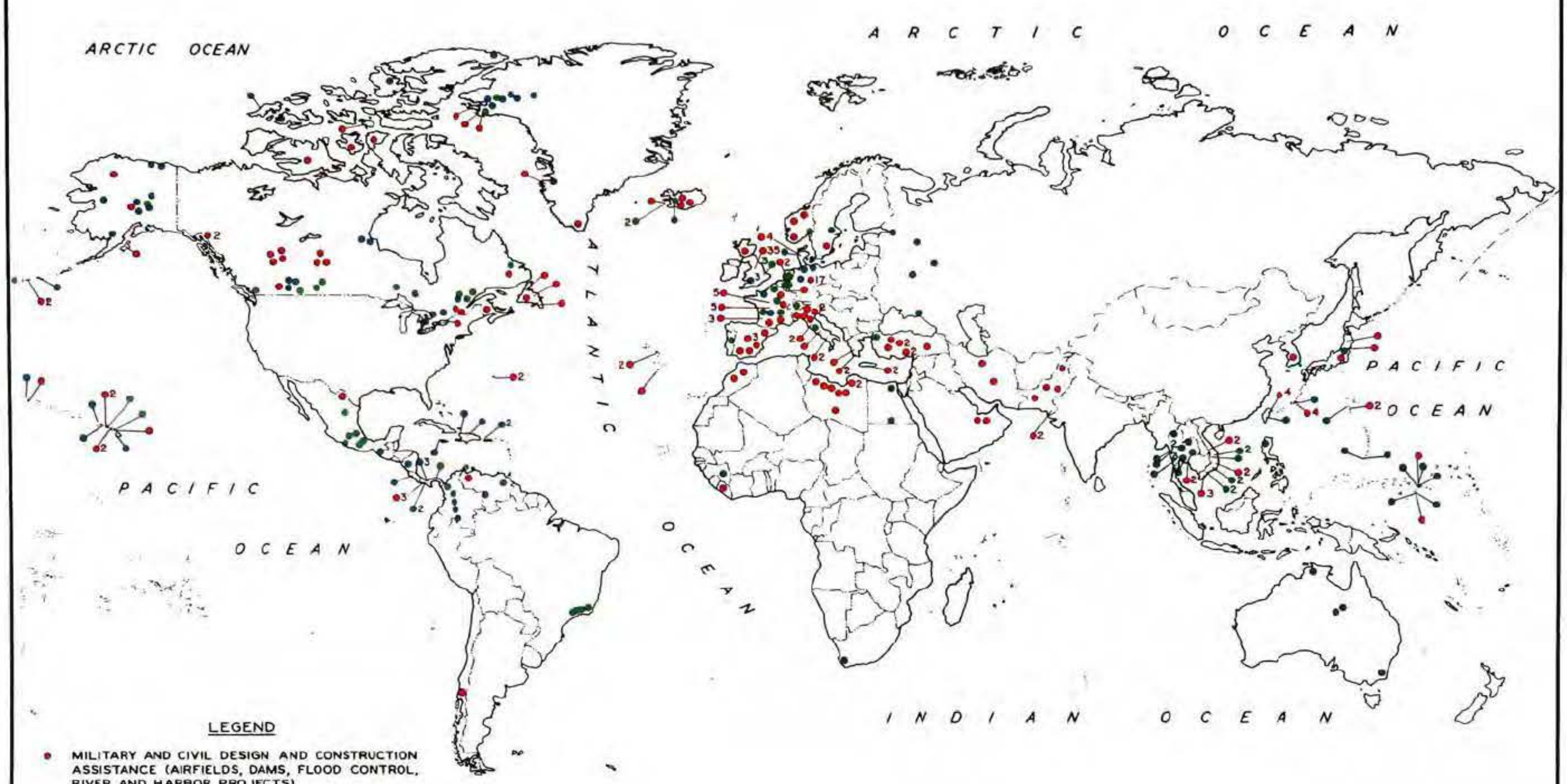
61. In addition to serving in an official capacity, many of the staff members are recognized experts in their respective fields and provide consulting services to agencies outside the Federal Government, such as state and local governments and contractors who have Government contracts. Some staff members also provide consulting services on a personal basis to consulting, engineering, and construction firms throughout the world.

Overseas Work

62. Soon after the beginning of World War II, the work of WES began to expand outside the continental limits of the United States, primarily as a result of the war effort. The accompanying world map (fig. 1) shows the distribution of the overseas projects. The legend and notes on the map are self-explanatory. The initial overseas work occurred principally in the Soils Division in connection with the evaluation and design and construction assistance on existing and new airfields, respectively. During and subsequent to the war effort, this work was expanding and was particularly evident in the Soils and Hydraulics Division. The Hydraulics Division work consisted largely of design and construction assistance, usually in the form of model studies in connection with river and harbor development.

63. In the late 1950's and early 1960's, overseas work on research and development projects was initiated. These projects were confined to the Soils, Mobility and Environmental (M&E), and Nuclear Weapons Effects (NWE) Divisions. The NWE research and development activities pertained largely to cratering and ground-motion studies, whereas the M&E work was confined, as the name implies, to mobility of military vehicles and studies in groundwater and vegetation environments in an effort to gain worldwide background for these projects. Some of the early Soils Division research and development projects were in connection with mobility and environmental work; however, most of them pertained to projects in connection with expedient surfacing such as landing mats, membranes, and soil stabilization. The work of the Concrete Division was in the form of military construction assistance in designing concrete mixtures, particularly in cold climates.

64. The Soils, Hydraulics, and M&E Divisions were involved in certain miscellaneous projects that consisted largely of attendance at international meetings and conferences, consulting services, lectures, conducting training schools, and official exchange visits. In this latter category, Mr. Turnbull visited Russia in September 1959 as a member of an American delegation of soil and foundation engineers for the purpose of studying Soviet research, design, construction, and education in the field of soil and foundation engineering. Mr. Tiffany visited the USSR in September 1961 as a member of a U. S. exchange delegation of hydraulic laboratory directors for



LEGEND

- MILITARY AND CIVIL DESIGN AND CONSTRUCTION ASSISTANCE (AIRFIELDS, DAMS, FLOOD CONTROL, RIVER AND HARBOR PROJECTS)
- RESEARCH AND DEVELOPMENT (STUDIES OF GROUND MOBILITY AND ENVIRONMENTAL EFFECTS FOR MILITARY VEHICLES, EXPEDIENT AIRFIELD SURFACING, BLAST EFFECTS AND GROUND MOTION, ENGINEERING PROJECTS IN ARCTIC ENVIRONMENTS)
- MISCELLANEOUS (ATTENDANCE AT INTERNATIONAL MEETINGS AND CONFERENCES, CONSULTATION SERVICES, LECTURES, AND OFFICIAL EXCHANGE VISITS)

NOTE: SYMBOLS NOT NECESSARILY IN EXACT PROJECT LOCATIONS. SINGLE SYMBOL WITH NO NUMBER REPRESENTS ONE ACTIVITY. WHEN GEOGRAPHIC AREA OR EXTENT OF ACTIVITY REQUIRES, A NUMBER IS USED BESIDE SYMBOL TO REPRESENT NUMBER OF PROJECTS IN INDICATED COUNTRY

OVERSEAS ACTIVITIES OF THE WATERWAYS EXPERIMENT STATION

the purpose of obtaining technical information on hydraulic laboratory operations in Russia.

65. The table which follows shows a general breakdown of the overseas projects among the several divisions. From the table, it is noted that a total of 407 projects outside the continental limits of the United States were accomplished. Of these projects, 232 were in connection with military or civil design and construction assistance work, 88 concerned research and development, and 87 were miscellaneous.

WES Activity Outside the United States

WES Technical Division	Type of Project and No.		
	Military or Civil Construction Assistance	Research and Development	Miscellaneous*
Concrete	3	1	22
Hydraulics	11	--	6
Nuclear Weapons Effects	--	9	--
Mobility and Environmental	--	17**	2
Soils	218	61	57
Total	232	88	87

* Attendance at international meetings and conferences, consulting services, lectures, conducting training schools, and official exchange visits.

** Work was carried on in several specific locations for each of several of these projects.

1953 Tornado

66. The tornado that struck Vicksburg on Saturday evening, 5 December 1953, did extensive damage to the downtown industrial and business districts and to the residential areas in the northeastern part of the city. The Director of the Station, COL C. H. Dunn, was notified of the disaster almost immediately and requested to provide personnel, supplies, and equipment. A complete summary of actions taken and services provided is contained in Appendix XXIII.

Long-Range Master Plan

67. During the Annual Inspection by the team from OCE on 7-8 October 1963, the Director was requested to develop a long-range plan for the WES. To be included was a study of the mission; long-range work forecast; review of adequacy of existing facilities in relation to the forecasted work load; and recommendations concerning a long-range plan of development over the next five to ten years.

68. The study was initiated immediately with a completion target date

scheduled to coincide with the FY 65 Annual Inspection. The Director, COL Alex G. Sutton, Jr., presented a brief oral summary of the initial plan at the Annual Inspection on 29 September 1964 and the written version was transmitted to the Chief of Engineers by letter dated 9 October 1964. This initial report was approved with a few minor exceptions.

69. An updated version of the Long-Range Plan was submitted to the Chief of Engineers on 25 April 1967 and is currently being revised.

The Future of the Waterways Experiment Station

70. Although the future of any Government installation can be determined by the stroke of a pen or decision of a single individual, the scope of activity and capability of the WES staff are such that it can be assumed that WES will continue as an organization indefinitely. The name may be changed, the mission altered, the chain of authority revised, but WES will continue as one of the leading governmental research and experimental organizations in the country. It is estimated that future growth, program and personnel, will continue to increase although at a slower rate than in the past. Total programs in the next 20 years should increase from the present 18.6 million dollars (in-house) to about 25 million dollars (in-house) and the personnel staff from its present level of 1300 to about 1800. The type of program to be carried out will depend upon the conditions of the time. Emphasis will be given research on military problems if wartime activity predominates, whereas emphasis will be shifted to civil problems in the event of a cessation of hostilities. In any event, it is expected that the military program of work will continue to exceed the civil program. The latter program will give increased emphasis to all phases of water resource problems.

71. Technical ability of the professional staff will continue to improve at an ever-increasing rate as a result of increased emphasis on education and the advanced study programs sponsored by the Government. Increased skills being developed in computer applications will call for access to larger and larger computers. It is estimated that computer activities at WES will increase manyfold, and practically all data analyses and drafting will be accomplished by computers. Increased use of computers will require more sophisticated and expensive instrumentation for the recording of data in a form for ready computer analysis. Personnel of the technical divisions will become more computer-oriented and will develop an increased capability to program their own problems.

72. As regards physical facilities, it is estimated that additions will be made to all existing office buildings to accommodate a gradually increasing staff. A separate building to house Construction Services Division personnel will be constructed in the vicinity of the present Shops Building; space presently occupied will be utilized by the Soils Division. These additions plus the completion of the new

Concrete Division building and construction of a Computer building should provide adequate office facilities for a staff of 1800 persons. Land costs make unlikely the acquisition of new property adjacent to the Vicksburg reservation. Requirements for additional test areas will be satisfied by short-term rental agreements for nearby sites and by utilization of the Jackson Installation. The 155 acres east of Porters Chapel Road recently procured will be policed to ensure efficient utilization of the space for test purposes. About 500,000 sq ft of covered area will be provided by shelter construction in the new area within the next five years. It is anticipated that WES will maintain title to all lands at the Jackson Installation and will maintain the Mississippi Basin model on a standby basis with intermittent operation as the occasion demands. The barracks-type buildings from World War II will be removed and all on-site personnel will be housed in the present Concrete Division building. Security and maintenance forces will be limited as much as possible.

73. Although revisions in the above-mentioned plans will be made as conditions and higher authority dictate, the plans as outlined represent the best forecast possible on the basis of past WES experience and projected work loads.

Appendix I

ORIGIN OF THE WATERWAYS EXPERIMENT STATION

by Herbert D. Vogel
Brigadier General, United States Army, Retired

The Waterways Experiment Station at Vicksburg, Mississippi, created and designed by the Corps of Engineers to meet a unique need, is the greatest institution of its kind in the world. River experimentation has been extended to include soils investigation and research, and since 1946 a concrete laboratory has become an outstanding addition. During the past 30 years, hundreds of problems relating to all parts of the United States and many foreign countries have been brought to it for study. Savings aggregating millions of dollars have been effected along with the improvement of hydraulic structure design. Thousands of visitors have come from all over the globe.

As a result of proof provided by the station as to the validity of models, engineers do not build large or expensive hydraulic structures today until they are first tested on a small scale. This is a complete revolution in engineering concepts.

In 1930, when ground was broken for the station, most hydraulic engineers thought of models as mere toys for the youngsters of the profession. A very large group was openly skeptical and many voiced their disdain. This attitude was shared by many officers and civilian employees of the Corps, and a few held ill-concealed resentment of the newfangled approach. Some high officers actually feared that model testing imposed a threat to sound engineering based on theory and computations.

While the work and accomplishments of the Waterways Experiment Station have often been described the events leading to its establishment have not been included.

Early Models and Laboratories

No one can tell where or when the idea first appeared of using models to predict the action or effect of prototypes. Perhaps some caveman saw the usefulness of the wheel by rolling a small, round, flat stone on a smooth surface. But throughout the ages many things were undoubtedly done originally on a small scale. James Watt's teakettle was in effect a small model of the steam engine that was to follow.

Models of structures, machines, and even ships were made and tested long before it was deemed appropriate or feasible to experiment with small-scale replicas of hydraulic channels and rivers. It is recorded that Professor Rehbock was active in Karlsruhe about 1900, and some experiments relative to the Weser River were conducted in the Prussian laboratory at the Lock Island in Berlin as early as 1904.

Sometime just before the turn of the century, Prof. Hubert Engels of the Technical College at Dresden visited a number of educational institutions in the United States. At the University of Michigan a professor of hydraulics was using a glass-sided flume to demonstrate the flow over a weir. This so impressed Professor Engels that upon his return to Germany he built a small laboratory in a basement at his college. The idea was taken up, and similar laboratories soon appeared in other technical colleges, notably at Karlsruhe and at Delft in Holland where Dr. J. Th. Thijsse was a professor of hydraulics. Other laboratories were established during the next few years in France, Italy, and Czechoslovakia. The installation of the Prussian Government in Berlin had grown in size and reputation, and its personnel worked closely with professors of the adjacent Berliner Technische Hochschule.

A year before World War I, John R. Freeman, an engineer of Providence, Rhode Island, saw the hydraulic laboratory in Dresden while visiting there. Four years later he found that the original laboratory had been completely rebuilt and that new ones had also risen at Karlsruhe and Delft. In 1925 he noted a rapid extension of the idea throughout Europe, and his quickened interest led to the establishment of a traveling fellowship to be awarded each year in his name by the American Society of Civil Engineers.

Campaign for U. S. Laboratory

By 1927, Freeman's enthusiasm for this new science had increased to the point that he felt compelled to campaign for the establishment of a hydraulic laboratory by some agency of the United States Government. The Corps of Engineers being cool to the idea, he turned to the Bureau of Standards for sympathetic attention and in so doing gained the ear of Herbert Hoover, who was then Secretary of Commerce.

To promote his aims in the United States, Freeman commissioned Samuel Shulits, a young American postgraduate student, to translate from German to English a work on hydraulic laboratories by Professor Schoklitsch of Brünn, Czechoslovakia. Shulits' work, completed about 1930, received final editing by Dr. Lorenz G. Straub of the University of Minnesota.

In 1928 Freeman managed to get a bill introduced in the Congress by Senator Joseph E. Ransdell of Louisiana to authorize construction of a hydraulic laboratory in the Bureau of Standards in Washington, D. C. The bill was passed in the Senate and reported to the House, where hearings were scheduled before the Committee on Rivers and Harbors on April 26 and 27, 1928.

At that time, Maj. Gen. Edgar Jadwin, Chief of Engineers, was engaged in the problems resulting from the 1927 flood on the Mississippi and had little time or opportunity to consider new and untried methods of research. He was taken by surprise, therefore, when Col. Ernest (Pot) Graves informed him that the House Committee on Rivers and Harbors would receive testimony from him on May 15. Both men realized that a laboratory in the Bureau would probably eliminate the possibility of attaining a laboratory for work on the Mississippi River.

With only a short time to prepare himself, General Jadwin went before the House Committee to point out that a laboratory for practical use with respect to work on the Mississippi was more essential at that time. General Jadwin emphasized the idea that a laboratory should be a tool of practical engineers and should be located not in Washington but close to the problems requiring solution. He said that it was necessary for a hydraulic laboratory, capable of dealing with the problems of the Mississippi and the similar alluvial rivers of the country, to be located on the Mississippi, where experiments could be carried on with the types of alluvium and sediment characteristic of the valley, and where laboratory personnel could be in contact with the field forces doing the actual river work, to check theoretical conclusions against practical observations.

The hearing continued at length, with discussions about the exact point on the Mississippi where a laboratory should be built and even the suggestion that perhaps it could be put on a barge to be moved where needed.

As a result of the Jadwin testimony, action toward the establishment of a National Hydraulic Laboratory was deferred by the House Committee. It appeared likely, however, that the issue would come up again in the next session of Congress, and the Chief of Engineers knew that he would need more information at that time.

Accordingly, he ordered Col. E. M. Markham and 1st Lt. John Paul Dean to visit all European laboratories during the late summer and fall of 1928. Colonel Markham returned on November 15, after about six weeks of travel, well armed with facts; Lieutenant Dean stayed on through the fall to obtain more detailed information.

Hearings before the House Committee were resumed on January 29, 1929, through February 28, when the Committee adjourned without action. The testimony given by Colonel Markham tended, in general, to belittle European progress. Comparison was drawn between American problems and theirs, and the conclusion was that in this country engineers would need to work with bigger models on a more flexible basis. Lieutenant Dean gave excellent testimony reinforcing this position. He pointed out that a laboratory built for problems of the Mississippi would require room to grow and that many models would have to be built outdoors with only temporary shelter provided.

Establishment

On June 18, 1929, General Jadwin directed the President of the Mississippi River Commission, then at St. Louis, to establish a hydraulic laboratory in the alluvial valley of the Mississippi at or near Memphis, Tennessee.*

The President of the Commission informed the District Engineer at Memphis, Lt. Col. F. B. Wilby, of the directive from the Chief and requested him to take the necessary steps to provide a suitable space for this laboratory in or adjacent

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* His authority for this was contained in the Mississippi River Flood Control Act, Public Law 391, 70th Congress, May 15, 1928.

to his shop and depot. At this time all that was needed was suitable space and a building of about 60 feet in width and 100 feet in length. The building was to be located in such a way that it could be extended to at least 200 feet when needed. It was directed that the building be a simple type of galvanized iron structure.

Plans for a building of the type described were all but completed when a telegram was received on November 16, by the Memphis District Engineer from the Chief of Engineers, Maj. Gen. Lytle Brown, which read, "Hydraulic Laboratory may be removed. Suspend all construction work on it." On November 25, advice was received from Maj. D. O. Elliott, assistant to the President, Mississippi River Commission, that the Commission headquarters were being moved from St. Louis to Vicksburg, Mississippi, and that the laboratory would go there, too. After looking over possible sites around Vicksburg, a report was submitted to the President of the Commission on December 9, recommending construction of a laboratory at a location on Durden Creek, 4 miles south of town. The new Chief of Engineers in approving the project stated that an experimental and research force, with the necessary personnel and equipment, should be set up at once and expanded according to need, and that the director of it should operate directly under the Division Engineer.

Purchase of the land for the station was approved by the Secretary of War on February 14, 1930, but problems still remained. The economic depression of the thirties was now in full swing, and by law there was a prohibition against making new appointments in the civil service. Also, all salaries were cut 15 percent.

Prior to acquisition of the land at Durden Creek, James G. Jobes, a young junior engineer recently graduated from the University of Michigan, and Isham H. Patty, an assistant engineer, whose basic education was in pharmacy, had been assigned to the station from the Vicksburg District. Hard pressed, with a tremendous flood-control construction project on their hands, district engineers could supply but little personnel. Willingham Woods of Washington, Georgia, a graduate of the Georgia Institute of Technology, was transferred from the Vicksburg District as a junior engineer, as were one or two others in the unclassified grades. For the most part it was necessary to employ college graduates as laborers at $100 a month less 15 percent. Unskilled labor, soon to become skilled in the trades, was paid $65 less 15 percent.

The silver lining to this cloud was that during its formative years the experiment station gained a staff of young, brilliant engineers, who were willing to undertake any task, whatever the challenge. None had lifetime theories to uphold, and any one of them would have been glad to prove Sir Isaac Newton wrong. All were iconoclasts in that sense.

This was the spirit needed to instill life in the facility which had been created. A dam had been built and water was being impounded with every rain. The main building, emblazoned with an engineer castle over its main entrance, was serving as a workshop and office. Costs had gone far beyond those anticipated but Brig. Gen. T. H. Jackson, president, and Maj. P. S. Reinecke, assistant to the president of the Mississippi River Commission, had become extremely interested and approval was given to additional requests for funds.

First Projects

During the first summer, 1930, Prof. Clarence Bardsley went to Vicksburg from the Missouri School of Mines to work as an assistant. Just after his arrival, General Jackson asked if it would be possible to build a model of the Illinois River and through work with it to establish the limit of backwater from the Mississippi. This problem would have been relatively simple with all anticipated facilities available and plenty of time to do the job. But results were needed in 30 days, and there was little to work with except a source of water. This was the first real challenge. If refused, the entire approach might be discredited.

Templates were cut from sheet steel and fitted to the ground which Bardsley carved out with a grapefruit knife to form a miniature river channel. A weir box was built, and the weir was calibrated. The loess soil of the experiment station grounds could be carved and made to withstand erosion for this test, but it was a one-time success. Once disturbed, the soil became dust and, even though compacted, could not be carved again.

As a result of tests, the limit of Mississippi backwater on the Illinois River was reported as being at Mile 120, and Congress so established it. Then came the problem of determining backwater in the Yazoo Delta. This was quite a different undertaking.

A large model, representing 100 miles or so of the Mississippi River, was needed; and the backwater area would be of considerable extent. The expedient of building on bare ground could not be used as it had been for the Illinois River model. So much area was involved that it would be necessary to concrete the entire surface. The next problem was to decide upon suitable scales. The model could not be too large for the available space and cost was a major factor. With the predicted savings engendered by models a thing to be proved, those in authority would not look with favor upon large expenditures. A horizontal scale of 1 to 2,000 would have been chosen except that graph paper was available only with subdivisions in multiples of 12. Metric paper could not be found. So a scale of 1 to 2,400 was finally selected. This introduced doubts and fears, because European experience had led to a belief that a scale of 1 to 300 was extremely small. And it was necessary, too, to sidestep European principles in the matter of distortion. Measurable depths and proper characteristics of flow could be obtained only with a vertical scale of at least 1 to 120, so a 20:1 distortion was employed. This opened a new chapter in the design and construction of river models.

With the main building of the station completed and equipped, new problems were undertaken in the next few months. A model was built to determine the distribution of flow through the Bonnet Carré floodway. The means of protecting railroad embankments subject to overflow were tested in full scale in the creek downstream from the laboratory. Also, an indoor model was built to determine the effects of cutoffs in the Greenville Bends.

Research Activities and Growth

The next summer, as the result of a request by Lt. Paul W. Thompson, he and a number of other lieutenants were sent to study at the station during the time between completion of their graduate work at civilian universities and their assignment to the Engineer School at Fort Belvoir. This provided a means of undertaking a number of research problems, one of which related to the movement of sediment in a forked flume and another to types of flow to be found at river bends.

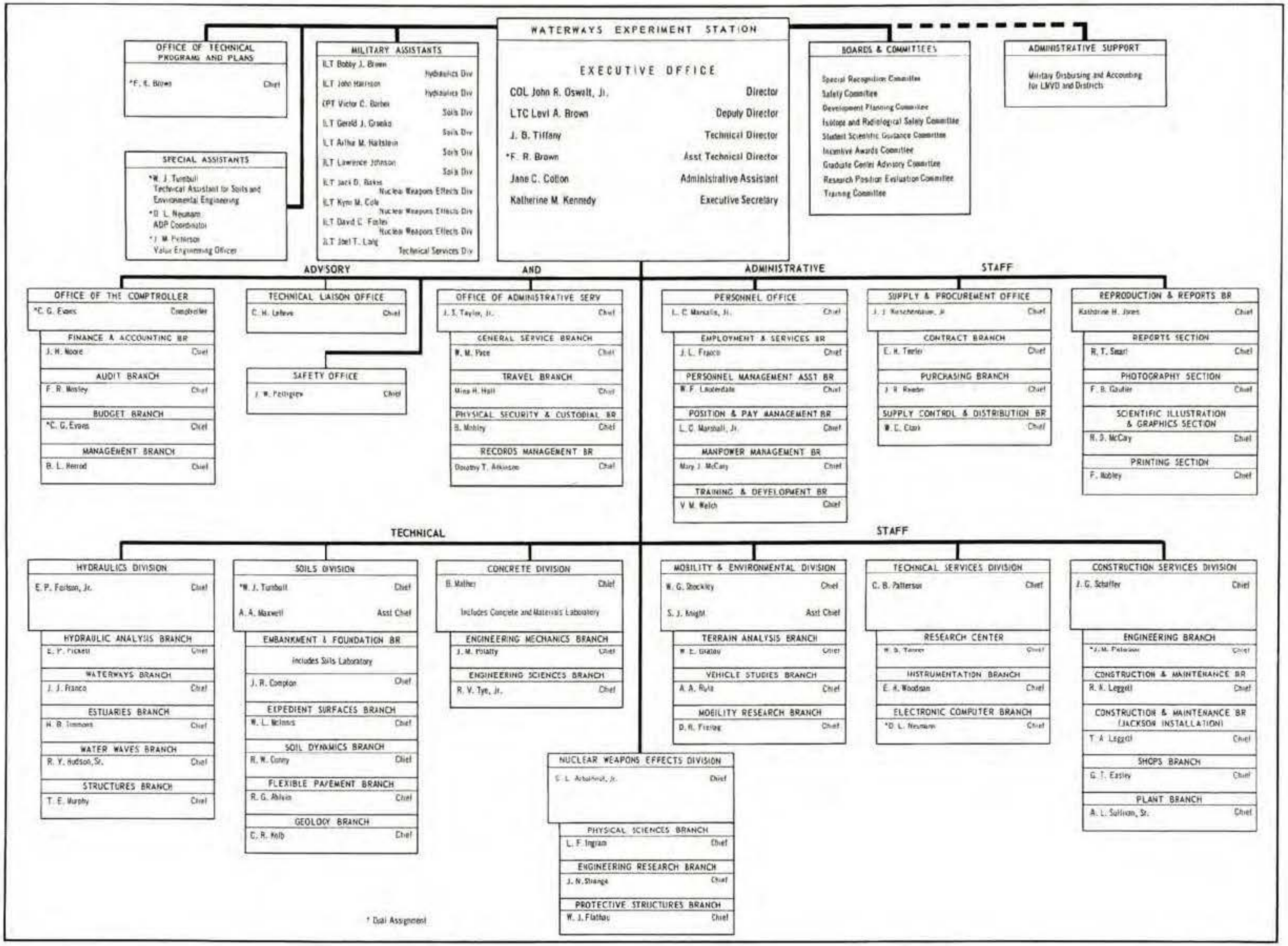
The science being new in this country and many new problems being encountered because of the magnitude of the prototype rivers, a need for new methods and materials was soon felt. The engineers of the station set out to try everything they could imagine. When instruments were lacking, substitutes were improvised, and many discoveries emerged. One such invention was the Bentzel tube, later produced commercially to measure low-velocity flows.

Gradually, an organization was formed to undertake and prosecute problems in an orderly fashion. It is not possible here to name all the engineers who contributed to the early success of the station, but no record would be complete that did not acknowledge the very great contributions of Joe Tiffany, who came to the station straight from the University of Illinois and who has stayed through all the years. The story of Joe Tiffany is the story of the Waterways Experiment Station; and if he is ever so disposed, he can tell it from this point on.

(from The Military Engineer, March-April 1961, Vol 53, No. 352, pp 132-135)

APPENDIX II

PRESENT ORGANIZATION CHART OF WATERWAYS
EXPERIMENT STATION

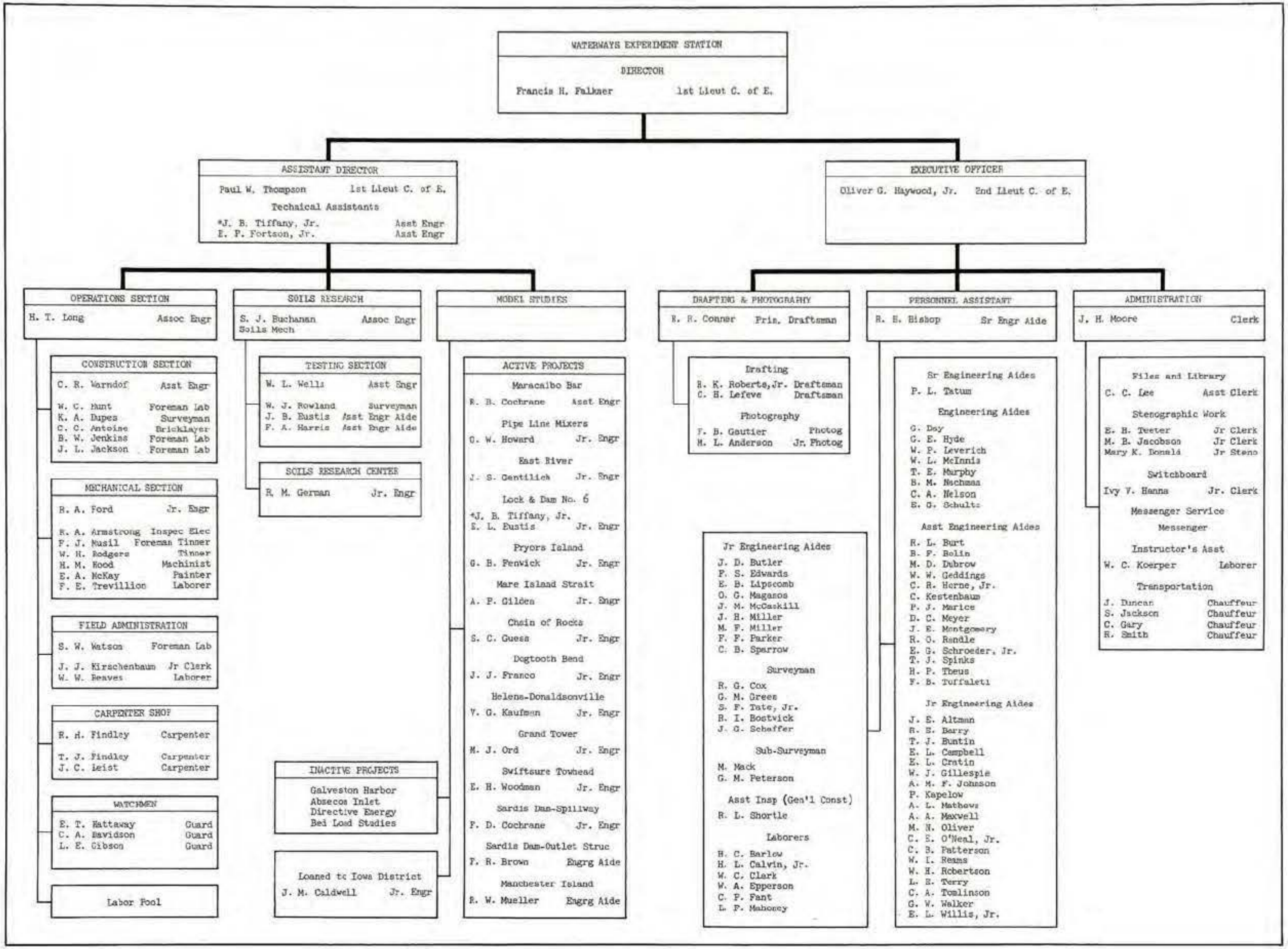


WATERWAYS EXPERIMENT STATION
EXECUTIVE OFFICE
COL John R. Oswalt, Jr. Director
LTC Levi A. Brown Deputy Director
J. B. Tiffany Technical Director
*F. R. Brown Asst Technical Director
Jane C. Cotton Administrative Assistant
Katherine M. Kennedy Executive Secretary
OFFICE OF TECHNICAL PROGRAMS AND PLANS
*F. R. Brown Chief
SPECIAL ASSISTANTS
*W. J. Turnbull
Technical Assistant for Soils and Environmental Engineering
*D. L. Neumann
ADP Coordinator
*J. M. Peterson
Value Engineering Officer
MILITARY ASSISTANTS
1LT Bobby J. Brown Hydraulics Div
1LT John Harrison Hydraulics Div
CPT Victor C. Barber Soils Div
1LT Gerald J. Grabko Soils Div
1LT Arthur M. Hartstein Soils Div
1LT Lawrence Johnson Soils Div
1LT Jack D. Bakes Nuclear Weapons Effects Div
1LT Kym M. Cole Nuclear Weapons Effects Div
1LT David C. Foster Nuclear Weapons Effects Div
2LT Joel T. Lang Technical Services Div
BOARDS & COMMITTEES
Special Recognition Committee
Safety Committee
Development Planning Committee
Isotope and Radiological Safety Committee
Student Scientific Guidance Committee
Incentive Awards Committee
Graduate Center Advisory Committee
Research Position Evaluation Committee
Training Committee
ADMINISTRATIVE SUPPORT
Military Disbursing and Accounting for LMVD and Districts
ADVISORY AND ADMINISTRATIVE STAFF
OFFICE OF THE COMPTROLLER
*C. G. Evans Comptroller
FINANCE & ACCOUNTING BR
J. H. Moore Chief
AUDIT BRANCH
F. R. Wesley Chief
BUDGET BRANCH
*C. G. Evans Chief
MANAGEMENT BRANCH
B. L. Herrod Chief
TECHNICAL LIAISON OFFICE
C. H. Lefeve Chief
SAFETY OFFICE
J. W. Pettigrew Chief
OFFICE OF ADMINISTRATIVE SERV
J. S. Taylor, Jr. Chief
GENERAL SERVICE BRANCH
W. M. Pace Chief
TRAVEL BRANCH
Mina H. Hall Chief
PHYSICAL SECURITY & CUSTODIAL BR
B. Mobley Chief
RECORDS MANAGEMENT BR
Dorothy T. Atkinson Chief
PERSONNEL OFFICE
L. C. Marsalis, Jr. Chief
EMPLOYMENT & SERVICES BR
J. L. Franco Chief
PERSONNEL MANAGEMENT ASST BR
W. F. Lauderdale Chief
POSITION & PAY MANAGEMENT BR
L. C. Marshall, Jr. Chief
MANPOWER MANAGEMENT BR
Mary J. McCary Chief
TRAINING & DEVELOPMENT BR
V. M. Welch Chief
SUPPLY & PROCUREMENT OFFICE
J. J. Reschenbaum, Jr. Chief
CONTRACT BRANCH
E. H. Teeler Chief
PURCHASING BRANCH
J. R. Reeder Chief
SUPPLY CONTROL & DISTRIBUTION BR
W. C. Clark Chief
REPRODUCTION & REPORTS BR
Katharine H. Jones Chief
REPORTS SECTION
R. T. Smart Chief
PHOTOGRAPHY SECTION
F. B. Gautier Chief
SCIENTIFIC ILLUSTRATION & GRAPHICS SECTION
R. D. McCay Chief
PRINTING SECTION
F. Mobley Chief
TECHNICAL STAFF
HYDRAULICS DIVISION
E. P. Fortson, Jr. Chief
HYDRAULIC ANALYSIS BRANCH
E. P. Pickett Chief
WATERWAYS BRANCH
J. J. Franco Chief
ESTUARIES BRANCH
H. B. Simmons Chief
WATER WAVES BRANCH
R. Y. Hudson, Sr. Chief
STRUCTURES BRANCH
T. E. Murphy Chief
SOILS DIVISION
*W. J. Turnbull Chief
A. A. Maxwell Asst Chief
EMBANKMENT & FOUNDATION BR
Includes Soils Laboratory
J. R. Compton Chief
EXPEDIENT SURFACES BRANCH
W. L. McInnis Chief
SOIL DYNAMICS BRANCH
R. W. Cunny Chief
FLEXIBLE PAVEMENT BRANCH
R. G. Ahlvin Chief
GEOLOGY BRANCH
C. R. Kolb Chief
CONCRETE DIVISION
B. Mather Chief
Includes Concrete and Materials Laboratory
ENGINEERING MECHANICS BRANCH
J. M. Polatty Chief
ENGINEERING SCIENCES BRANCH
R. V. Tye, Jr. Chief
MOBILITY & ENVIRONMENTAL DIVISION
W. G. Shockley Chief
S. J. Knight Asst Chief
TERRAIN ANALYSIS BRANCH
W. E. Grabau Chief
VEHICLE STUDIES BRANCH
A. A. Rula Chief
MOBILITY RESEARCH BRANCH
D. R. Freitag Chief
TECHNICAL SERVICES DIVISION
C. B. Patterson Chief
RESEARCH CENTER
W. B. Tanner Chief
INSTRUMENTATION BRANCH
E. H. Woodman Chief
ELECTRONIC COMPUTER BRANCH
*D. L. Neumann Chief
CONSTRUCTION SERVICES DIVISION
J. G. Schaffer Chief
ENGINEERING BRANCH
*J. M. Peterson Chief
CONSTRUCTION & MAINTENANCE BR
R. K. Leggett Chief
CONSTRUCTION & MAINTENANCE BR (JACKSON INSTALLATION)
T. A. Leggett Chief
SHOPS BRANCH
G. T. Easley Chief
PLANT BRANCH
A. L. Sullivan, Sr. Chief
NUCLEAR WEAPONS EFFECTS DIVISION
G. L. Arbuthnot, Jr. Chief
PHYSICAL SCIENCES BRANCH
L. F. Ingram Chief
ENGINEERING RESEARCH BRANCH
J. N. Strange Chief
PROTECTIVE STRUCTURES BRANCH
W. J. Flathau Chief
* Dual Assignment

1 May 1968

APPENDIX III

PAST ORGANIZATION CHARTS OF WATERWAYS EXPERIMENT STATION


WATERWAYS EXPERIMENT STATION
DIRECTOR
Francis H. Falkner 1st Lieut C. of E.
ASSISTANT DIRECTOR
Paul W. Thompson 1st Lieut C. of E.
Technical Assistants
*J. B. Tiffany, Jr. Asst Engr
E. P. Fortson, Jr. Asst Engr
EXECUTIVE OFFICER
Oliver G. Haywood, Jr. 2nd Lieut C. of E.
OPERATIONS SECTION
H. T. Long Assoc Engr
CONSTRUCTION SECTION
C. R. Warndof Asst Engr
W. C. Hunt Foreman Lab
K. A. Dupes Surveyman
C. C. Antoine Bricklayer
B. W. Jenkins Foreman Lab
J. L. Jackson Foreman Lab
MECHANICAL SECTION
B. A. Ford Jr. Engr
R. A. Armstrong Inspec Elec
F. J. Musil Foreman Tinner
W. H. Rodgers Tinner
H. M. Hood Machinist
E. A. McKay Painter
F. E. Trevillion Laborer
FIELD ADMINISTRATION
S. W. Watson Foreman Lab
J. J. Kirschenbaum Jr Clerk
W. W. Beaves Laborer
CARPENTER SHOP
R. H. Findley Carpenter
T. J. Findley Carpenter
J. C. Leist Carpenter
WATCHMEN
E. T. Hattaway Guard
C. A. Davidson Guard
L. E. Gibson Guard
Labor Pool
SOILS RESEARCH
S. J. Buchanan Assoc Engr
Soils Mech
TESTING SECTION
W. L. Wells Asst Engr
W. J. Rowland Surveyman
J. B. Eustis Asst Engr Aide
F. A. Harris Asst Engr Aide
SOILS RESEARCH CENTER
R. M. German Jr. Engr
MODEL STUDIES
ACTIVE PROJECTS
Maracaibo Bar
R. B. Cochrane Asst Engr
Pipe Line Mixers
G. W. Howard Jr. Engr
East River
J. S. Gentilich Jr. Engr
Lock & Dam No. 6
*J. B. Tiffany, Jr.
E. L. Eustis Jr. Engr
Pryors Island
G. B. Fenwick Jr. Engr
Mare Island Strait
A. P. Gilden Jr. Engr
Chain of Rocks
S. C. Guess Jr. Engr
Dogtooth Bend
J. J. Franco Jr. Engr
Helena-Donaldsonville
V. G. Kaufman Jr. Engr
Grand Tower
M. J. Ord Jr. Engr
Swiftsure Towhead
E. H. Woodman Jr. Engr
Sardis Dam-Spillway
F. D. Cochrane Jr. Engr
Sardis Dam-Outlet Struc
F. R. Brown Engrg Aide
Manchester Island
R. W. Mueller Engrg Aide
INACTIVE PROJECTS
Galveston Harbor
Absecon Inlet
Directive Energy
Bed Load Studies
Loaned to Iowa District
J. M. Caldwell Jr. Engr
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R. R. Conner Prin. Draftsman
Drafting
R. K. Roberts, Jr. Draftsman
C. H. Lefeve Draftsman
Photography
F. B. Gautier Photog
M. L. Anderson Jr. Photog
PERSONNEL ASSISTANT
R. E. Bishop Sr Engr Aide
Sr Engineering Aides
P. L. Tatum
Engineering Aides
G. Day
G. E. Hyde
W. P. Leverich
W. L. McInnis
T. E. Murphy
B. M. Nachman
C. A. Nelson
E. G. Schultz
Asst Engineering Aides
R. L. Burt
B. F. Bolin
M. D. Dubrow
W. W. Geddings
C. R. Horne, Jr.
C. Kestenbaum
P. J. Marice
D. C. Meyer
J. E. Montgomery
R. O. Randle
E. G. Schroeder, Jr.
T. J. Spinks
H. P. Theus
F. B. Toffaleti
Jr Engineering Aides
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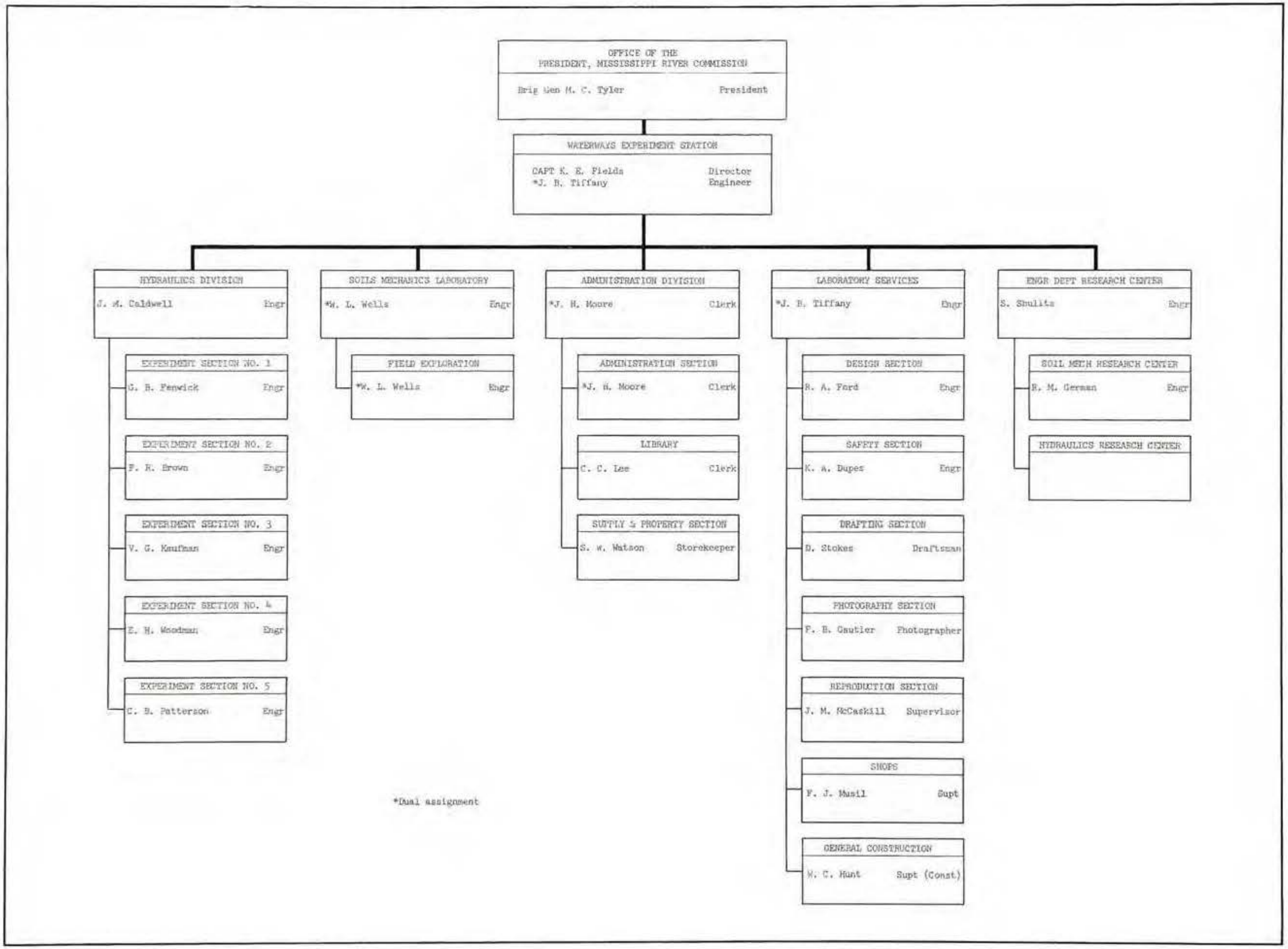
R. S. Barry
T. J. Buntin
E. L. Campbell
E. L. Cratin
W. J. Gillespie
A. M. F. Johnson
P. Kapelow
A. L. Mathews
A. A. Maxwell
M. N. Oliver
C. E. O'Neal, Jr.
C. B. Patterson
W. I. Reams
W. H. Robertson
L. E. Terry
C. A. Tomlinson
G. W. Walker
E. L. Willis, Jr.
Jr Engineering Aides
J. D. Butler
P. S. Edwards
E. B. Lipscomb
O. G. Magazos
J. M. McCaskill
J. H. Miller
M. F. Miller
F. F. Parker
C. B. Sparrow
Surveyman
R. G. Cox
G. M. Grees
S. F. Tate, Jr.
R. I. Bostwick
J. G. Schaffer
Sub-Surveyman
M. Mack
G. M. Peterson
Asst Insp (Gen'l Const)
R. L. Shortle
Laborers
H. C. Barlow
H. L. Calvin, Jr.
W. C. Clark
W. A. Epperson
C. P. Fant
L. F. Mahoney
ADMINISTRATION
J. H. Moore Clerk
Files and Library
C. C. Lee Asst Clerk
Stenographic Work
E. B. Teeter Jr Clerk
M. B. Jacobson Jr Clerk
Mary K. Donald Jr Steno
Switchboard
Ivy V. Hanna Jr. Clerk
Messenger Service
Messenger
Instructor's Asst
W. C. Koerper Laborer
Transportation
J. Duncan Chauffeur
S. Jackson Chauffeur
C. Gary Chauffeur
R. Smith Chauffeur

1 March 1937



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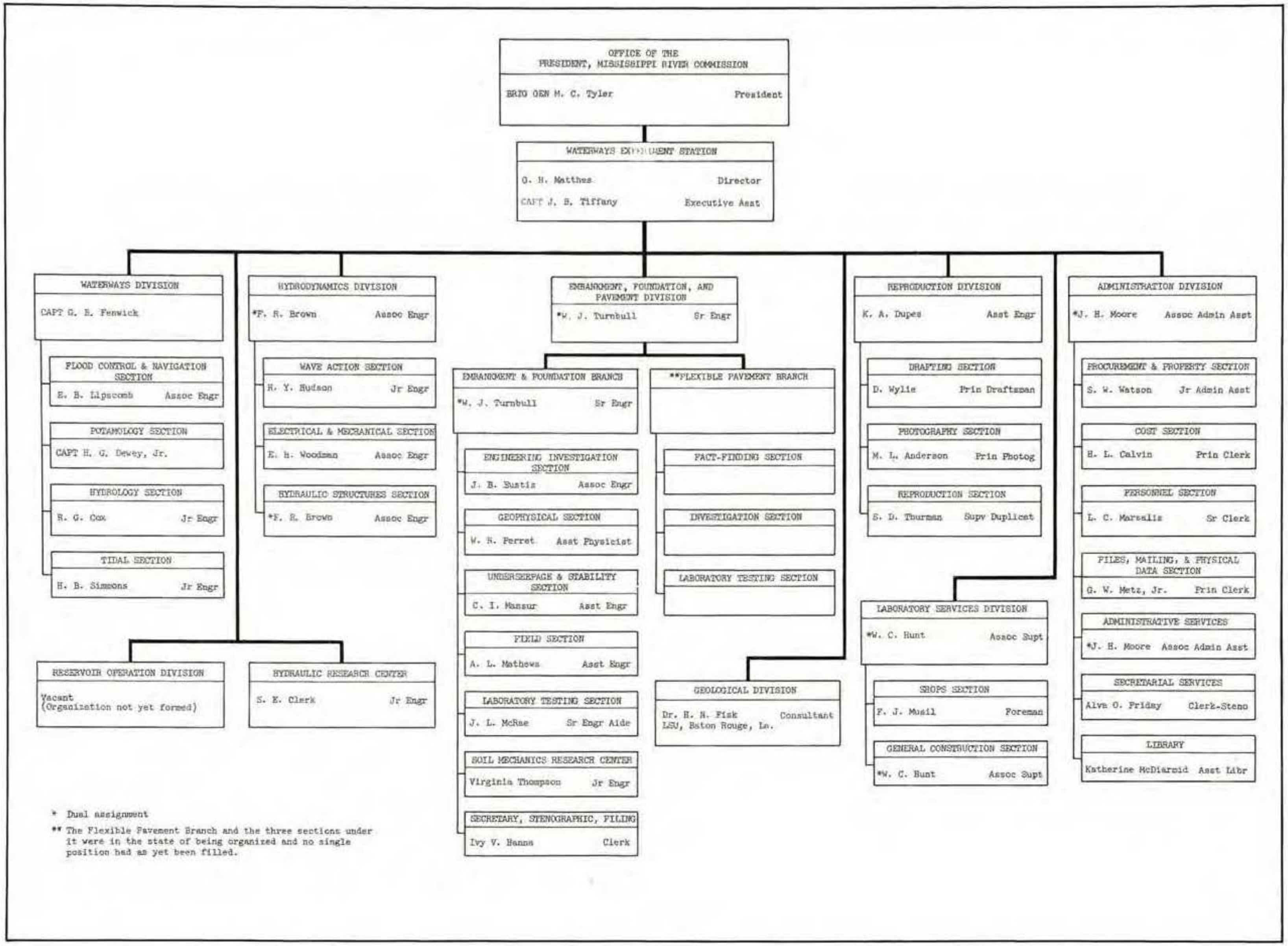

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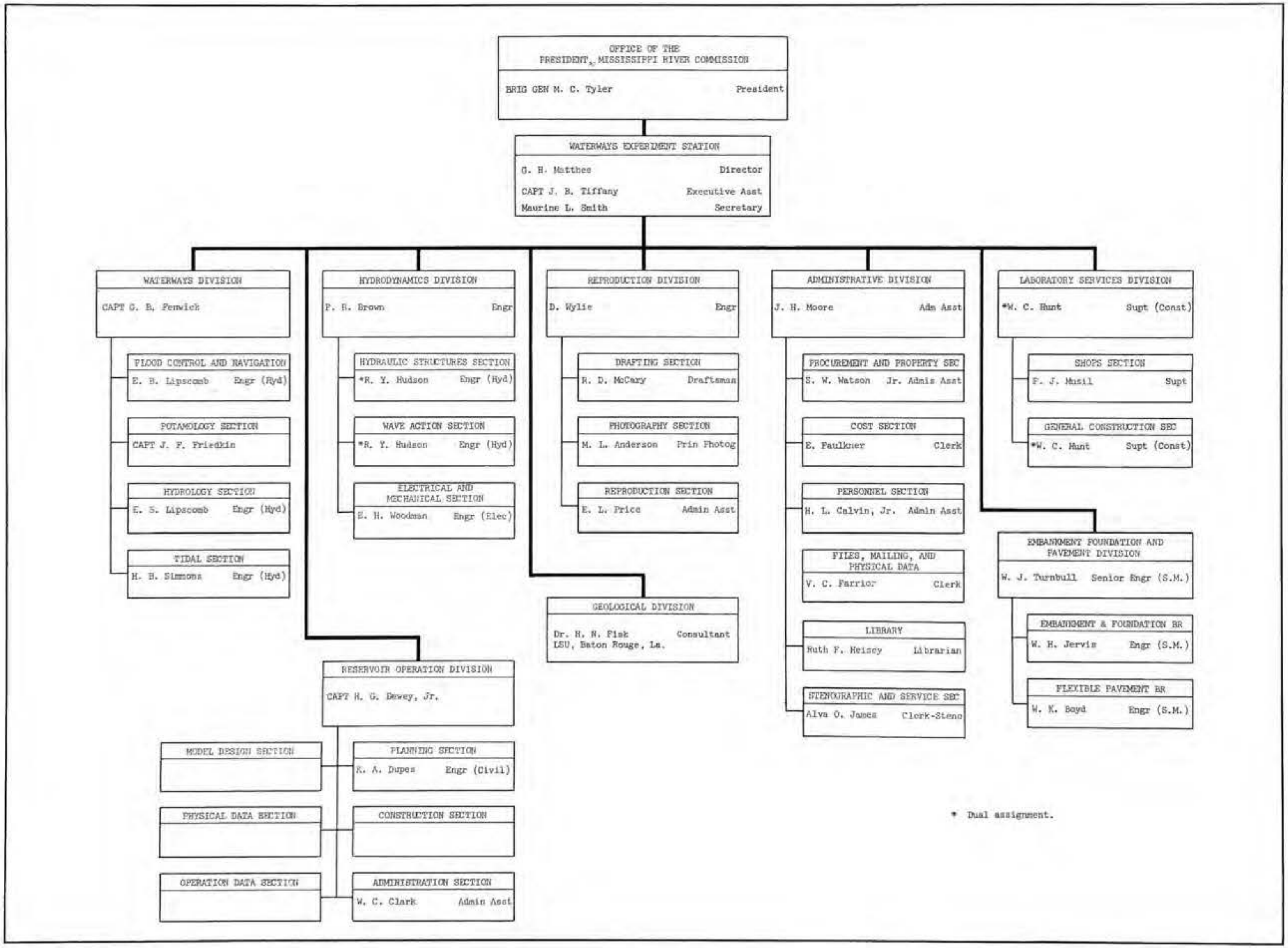
OFFICE OF THE PRESIDENT, MISSISSIPPI RIVER COMMISSION
BRIG GEN M. C. Tyler President
WATERWAYS EXPERIMENT STATION
G. H. Matthes Director
CAPT J. B. Tiffany Executive Asst
Maurine L. Smith Secretary
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CAPT J. F. Friedkin
HYDROLOGY SECTION
E. S. Lipscomb Engr (Hyd)
TIDAL SECTION
H. B. Simmons Engr (Hyd)
HYDRODYNAMICS DIVISION
F. B. Brown Engr
HYDRAULIC STRUCTURES SECTION
*R. Y. Hudson Engr (Hyd)
WAVE ACTION SECTION
*R. Y. Hudson Engr (Hyd)
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D. Wylie Engr
DRAFTING SECTION
R. D. McCary Draftsman
PHOTOGRAPHY SECTION
M. L. Anderson Prin Photog
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E. Faulkner Clerk
PERSONNEL SECTION
H. L. Calvin, Jr. Admin Asst
FILES, MAILING, AND PHYSICAL DATA
V. C. Farrior Clerk
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Ruth F. Heisey Librarian
STENOGRAPHIC AND SERVICE SEC
Alva O. James Clerk-Steno
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SHOPS SECTION
F. J. Musil Supt
GENERAL CONSTRUCTION SEC
*W. C. Hunt Supt (Const)
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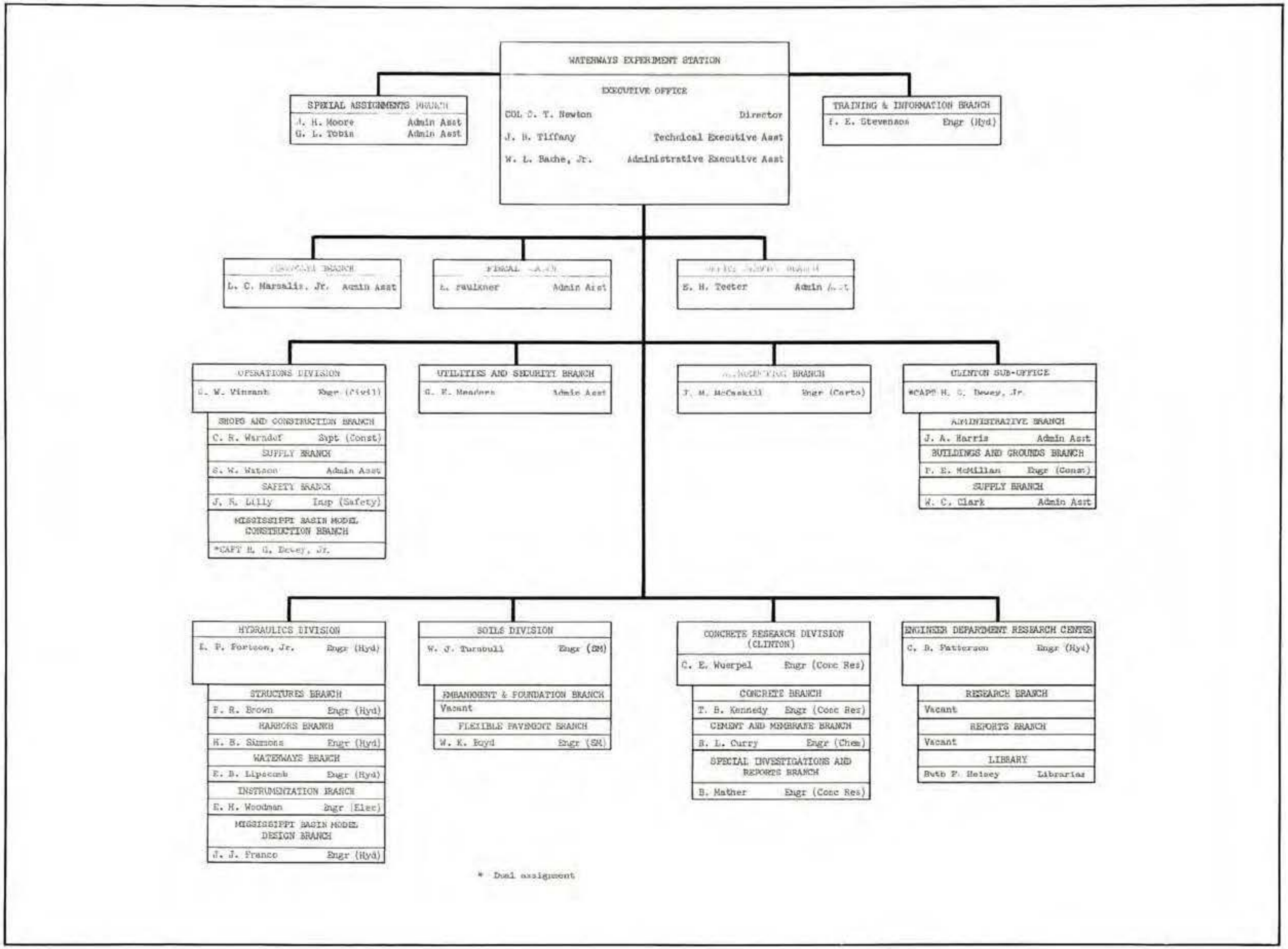
W. J. Turnbull Senior Engr (S.M.)
EMBANKMENT & FOUNDATION BR
W. H. Jervis Engr (S.M.)
FLEXIBLE PAVEMENT BR
W. K. Boyd Engr (S.M.)
GEOLOGICAL DIVISION
Dr. H. N. Fisk Consultant
LSU, Baton Rouge, La.
RESERVOIR OPERATION DIVISION
CAPT H. G. Dewey, Jr.
MODEL DESIGN SECTION
PHYSICAL DATA SECTION
OPERATION DATA SECTION
PLANNING SECTION
K. A. Dupes Engr (Civil)
CONSTRUCTION SECTION
ADMINISTRATION SECTION
W. C. Clark Admin Asst
* Dual assignment.

1 July 1944


WATERWAYS EXPERIMENT STATION
EXECUTIVE OFFICE
COL C. T. Newton Director
J. B. Tiffany Technical Executive Asst
W. L. Bache, Jr. Administrative Executive Asst
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J. H. Moore Admin Asst
G. L. Tobin Admin Asst
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L. C. Marsalis, Jr. Admin Asst
FISCAL
Faulkner Admin Asst
E. H. Teeter
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G. W. Vinzant Engr (Civil)
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S. W. Watson Admin Asst
SAFETY BRANCH
J. R. Lilly Insp (Safety)
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*CAPT H. G. Dewey, Jr.
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BRANCH
J. M. McCaskill Engr (Carto)
CLINTON SUB-OFFICE
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J. A. Harris Admin Asst
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F. E. McMillan Engr (Const)
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W. C. Clark Admin Asst
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E. P. Fortson, Jr. Engr (Hyd)
STRUCTURES BRANCH
F. R. Brown Engr (Hyd)
HARBORS BRANCH
H. B. Simmons Engr (Hyd)
WATERWAYS BRANCH
E. B. Lipscomb Engr (Hyd)
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E. H. Woodman Engr (Elec)
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J. J. Franco Engr (Hyd)
SOILS DIVISION
W. J. Turnbull Engr (SM)
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FLEXIBLE PAVEMENT BRANCH
W. K. Boyd Engr (SM)
CONCRETE RESEARCH DIVISION (CLINTON)
C. E. Wuerpel Engr (Conc Res)
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T. B. Kennedy Engr (Conc Res)
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B. L. Curry Engr (Chem)
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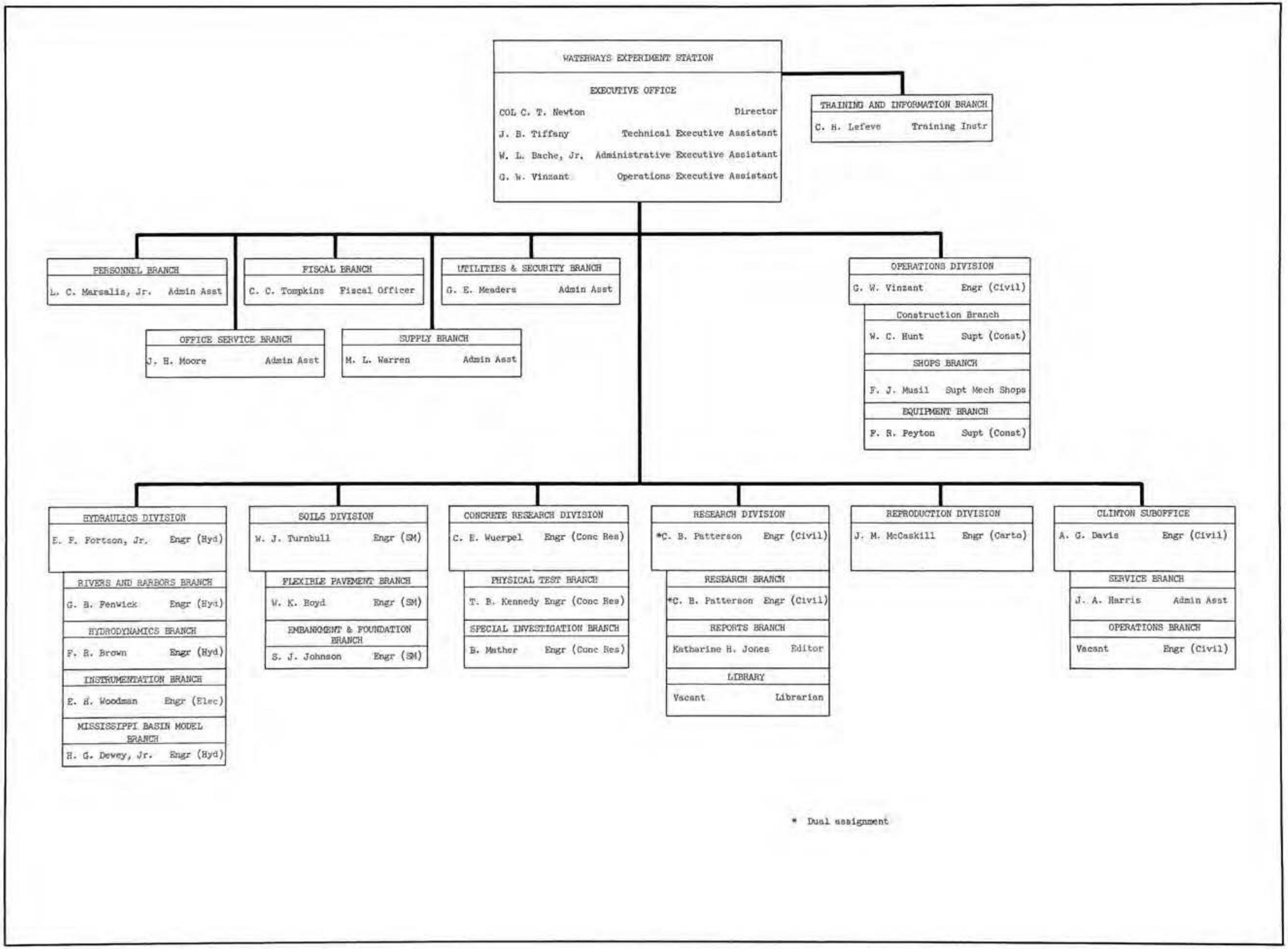
B. Mather Engr (Conc Res)
ENGINEER DEPARTMENT RESEARCH CENTER
C. B. Patterson Engr (Hyd)
RESEARCH BRANCH
Vacant
REPORTS BRANCH
Vacant
LIBRARY
Ruth F. Helsey Librarian
* Dual assignment

1 July 1946



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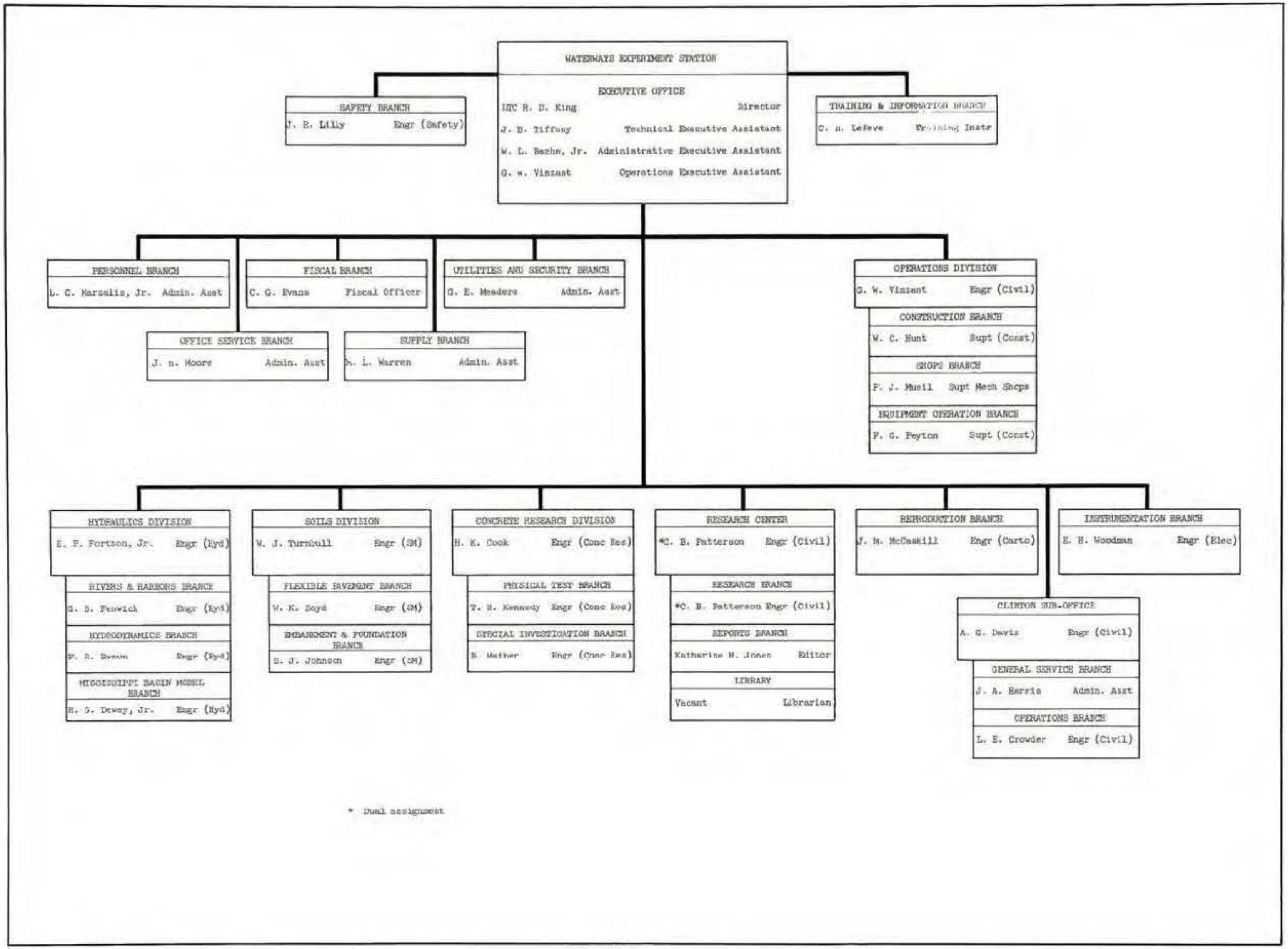
WATERWAYS EXPERIMENT STATION
EXECUTIVE OFFICE
LTC R. D. King Director
J. B. Tiffany Technical Executive Assistant
W. L. Bachm, Jr. Administrative Executive Assistant
G. W. Vinzant Operations Executive Assistant
SAFETY BRANCH
J. R. Lilly Engr (Safety)
TRAINING & INFORMATION BRANCH
C. H. Lefeve Training Instr
PERSONNEL BRANCH
L. C. Marsalis, Jr. Admin. Asst
FISCAL BRANCH
C. G. Evans Fiscal Officer
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J. H. Moore Admin. Asst
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H. L. Warren Admin. Asst
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G. W. Vinzant Engr (Civil)
CONSTRUCTION BRANCH
W. C. Hunt Supt (Const)
SHOPS BRANCH
F. J. Musil Supt Mech Shops
EQUIPMENT OPERATION BRANCH
F. G. Peyton Supt (Const)
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F. R. Brown Engr (Hyd)
MISSISSIPPI BASIN MODEL BRANCH
H. G. Dewey, Jr. Engr (Hyd)
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W. K. Boyd Engr (SM)
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S. J. Johnson Engr (SM)
CONCRETE RESEARCH DIVISION
H. K. Cook Engr (Conc Res)
PHYSICAL TEST BRANCH
T. B. Kennedy Engr (Conc Res)
SPECIAL INVESTIGATION BRANCH
B. Mather Engr (Conc Res)
RESEARCH CENTER
*C. B. Patterson Engr (Civil)
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*C. B. Patterson Engr (Civil)
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Katharine H. Jones Editor
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Vacant Librarian
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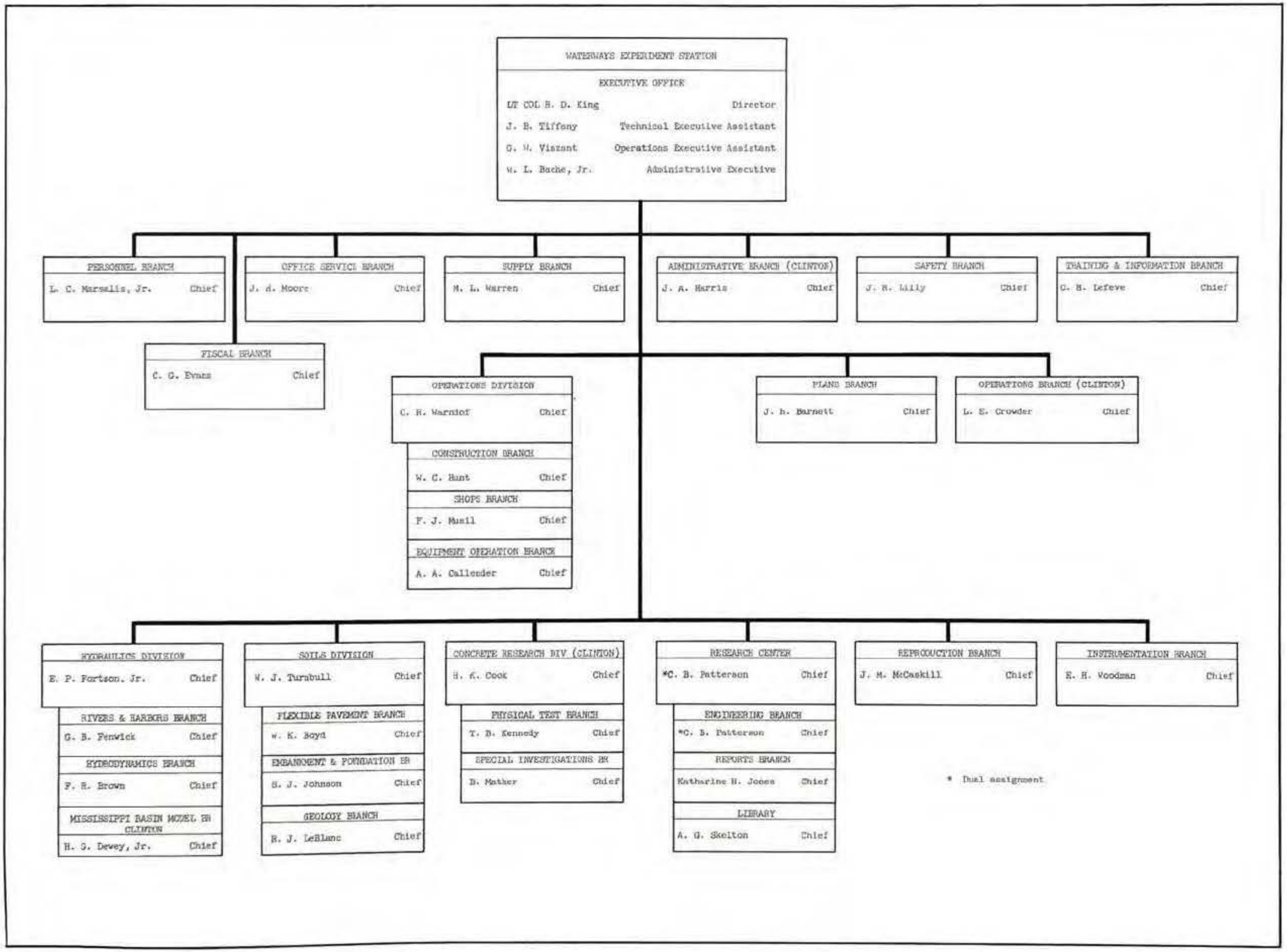
INSTRUMENTATION BRANCH
E. H. Woodman Engr (Elec)
CLINTON SUB-OFFICE
A. G. Davis Engr (Civil)
GENERAL SERVICE BRANCH
J. A. Harris Admin. Asst
OPERATIONS BRANCH
L. E. Crowder Engr (Civil)
* Dual assignment

1 July 1947



WATERWAYS EXPERIMENT STATION
EXECUTIVE OFFICE
LT COL B. D. King Director
J. B. Tiffany Technical Executive Assistant
G. W. Vinzant Operations Executive Assistant
W. L. Bache, Jr. Administrative Executive
PERSONNEL BRANCH
L. C. Marsalis, Jr. Chief
OFFICE SERVICE BRANCH
J. H. Moore Chief
SUPPLY BRANCH
M. L. Warren Chief
ADMINISTRATIVE BRANCH (CLINTON)
J. A. Harris Chief
SAFETY BRANCH
J. R. Lilly Chief
TRAINING & INFORMATION BRANCH
G. B. Lefeve Chief
FISCAL BRANCH
C. G. Evans Chief
OPERATIONS DIVISION
C. R. Warndof Chief
CONSTRUCTION BRANCH
W. C. Hunt Chief
SHOPS BRANCH
F. J. Musil Chief
EQUIPMENT OPERATION BRANCH
A. A. Callender Chief
PLANS BRANCH
J. H. Barnett Chief
OPERATIONS BRANCH (CLINTON)
L. E. Crowder Chief
HYDRAULICS DIVISION
E. P. Fortson, Jr. Chief
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G. B. Fenwick Chief
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F. R. Brown Chief
MISSISSIPPI BASIN MODEL BR CLINTON
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W. K. Boyd Chief
EMBANKMENT & FOUNDATION BR
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GEOLOGY BRANCH
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*C. B. Patterson Chief
ENGINEERING BRANCH
*C. B. Patterson Chief
REPORTS BRANCH
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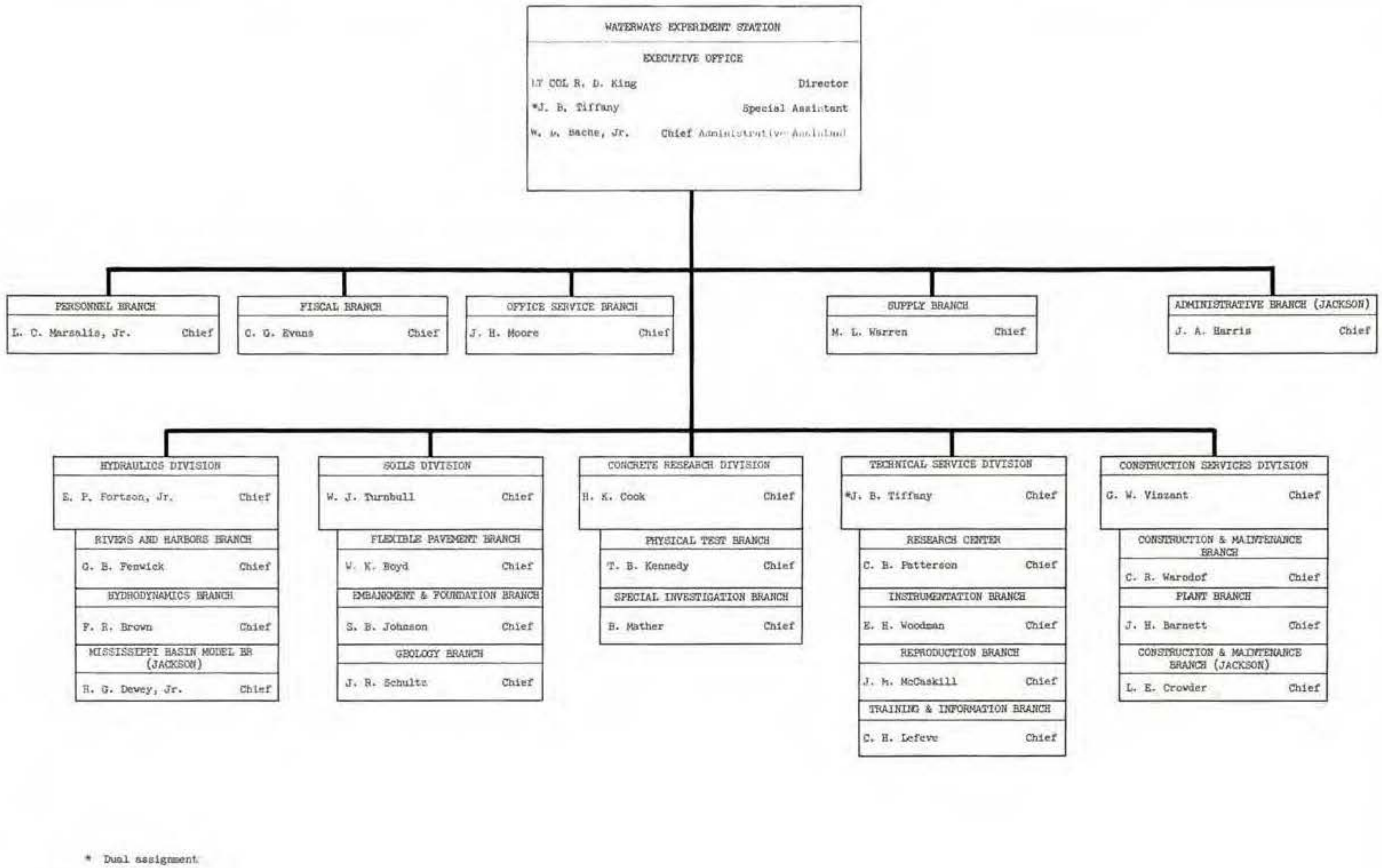
LIBRARY
A. G. Skelton Chief
REPRODUCTION BRANCH
J. M. McCaskill Chief
INSTRUMENTATION BRANCH
E. H. Woodman Chief
* Dual assignment

1 July 1948



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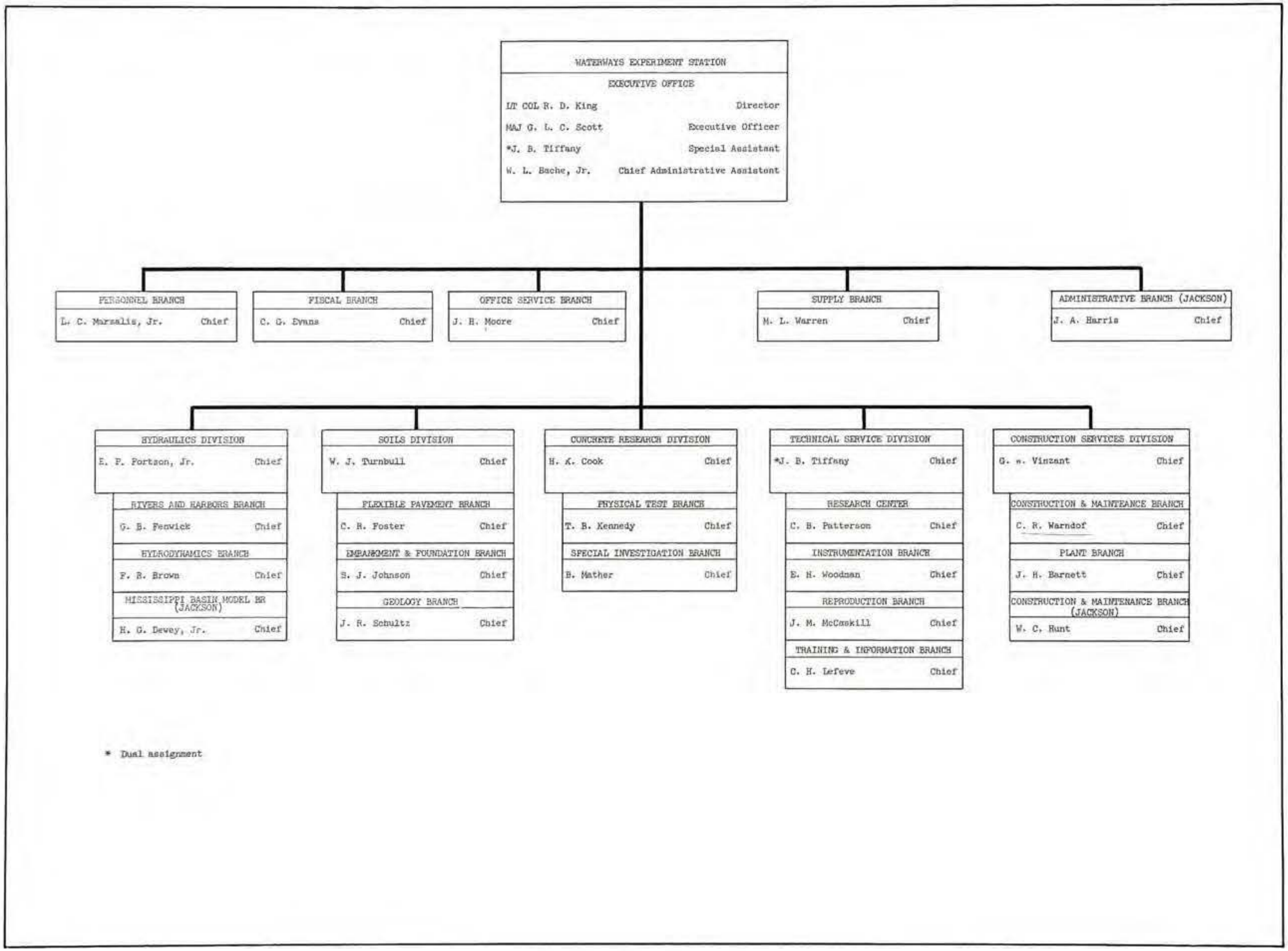
WATERWAYS EXPERIMENT STATION
EXECUTIVE OFFICE
LT COL R. D. King Director
MAJ G. L. C. Scott Executive Officer
*J. B. Tiffany Special Assistant
W. L. Bache, Jr. Chief Administrative Assistant
PERSONNEL BRANCH
L. C. Marsalis, Jr. Chief
FISCAL BRANCH
C. G. Evans Chief
OFFICE SERVICE BRANCH
J. H. Moore Chief
SUPPLY BRANCH
M. L. Warren Chief
ADMINISTRATIVE BRANCH (JACKSON)
J. A. Harris Chief
HYDRAULICS DIVISION
E. P. Fortson, Jr. Chief
RIVERS AND HARBORS BRANCH
G. B. Fenwick Chief
HYDRODYNAMICS BRANCH
F. B. Brown Chief
MISSISSIPPI BASIN MODEL BR (JACKSON)
H. G. Dewey, Jr. Chief
SOILS DIVISION
W. J. Turnbull Chief
FLEXIBLE PAVEMENT BRANCH
C. R. Foster Chief
EMBANKMENT & FOUNDATION BRANCH
S. J. Johnson Chief
GEOLOGY BRANCH
J. R. Schultz Chief
CONCRETE RESEARCH DIVISION
H. K. Cook Chief
PHYSICAL TEST BRANCH
T. B. Kennedy Chief
SPECIAL INVESTIGATION BRANCH
B. Mather Chief
TECHNICAL SERVICE DIVISION
*J. B. Tiffany Chief
RESEARCH CENTER
C. B. Patterson Chief
INSTRUMENTATION BRANCH
E. H. Woodman Chief
REPRODUCTION BRANCH
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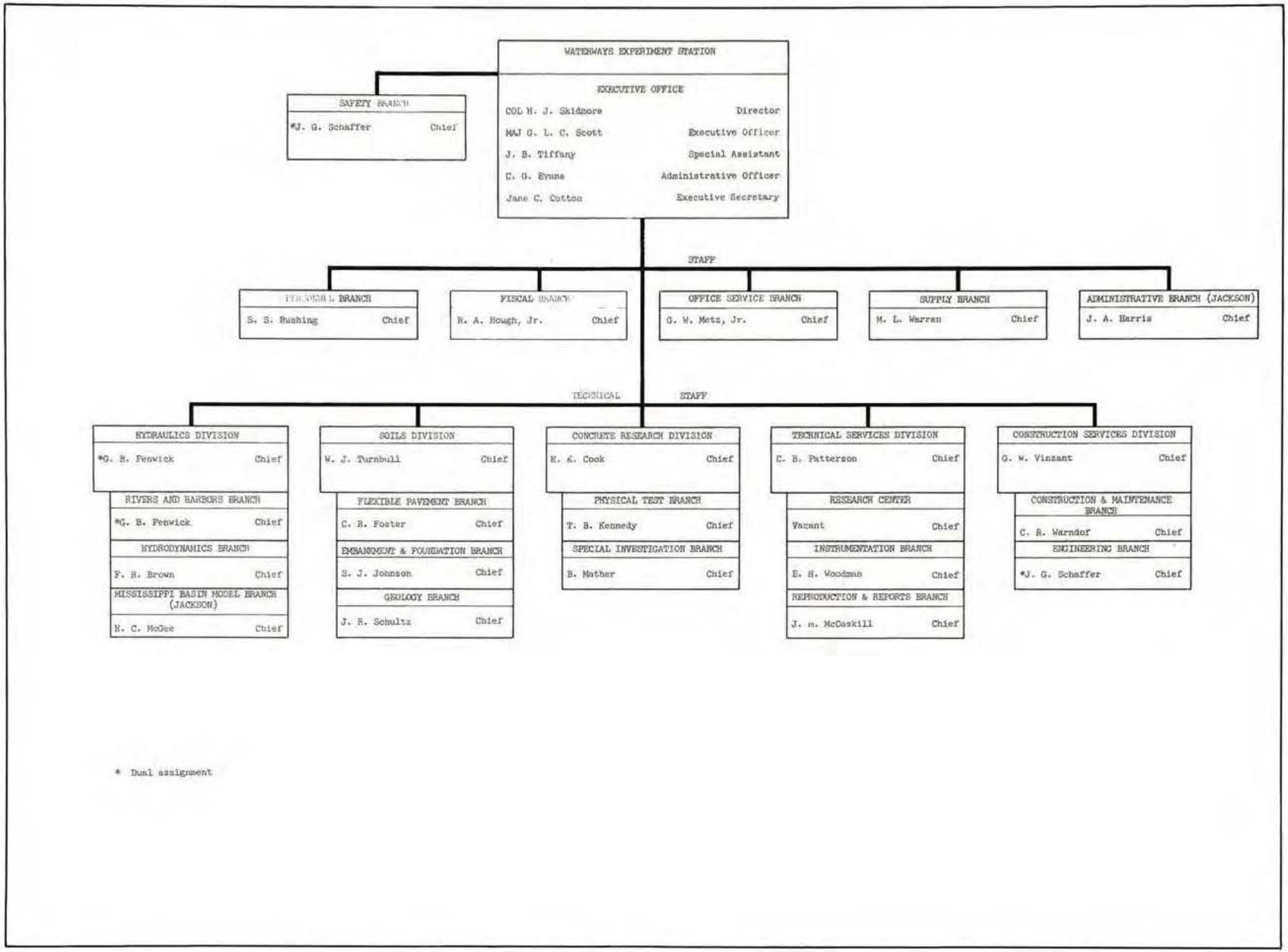
TRAINING & INFORMATION BRANCH
C. H. Lefeve Chief
CONSTRUCTION SERVICES DIVISION
G. W. Vinzant Chief
CONSTRUCTION & MAINTENANCE BRANCH
C. R. Warndof Chief
PLANT BRANCH
J. H. Barnett Chief
CONSTRUCTION & MAINTENANCE BRANCH (JACKSON)
W. C. Hunt Chief
* Dual assignment

1 July 1950



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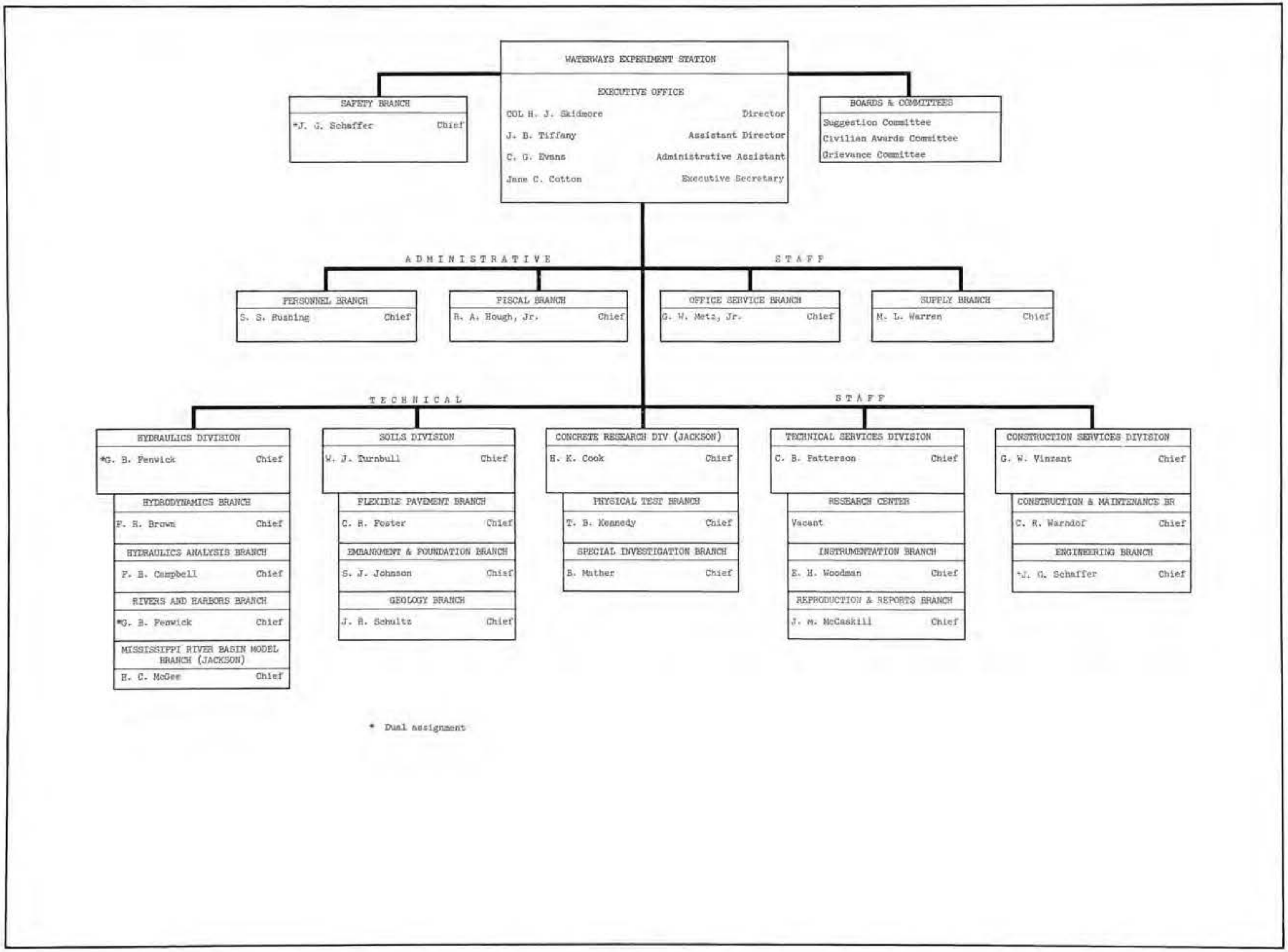
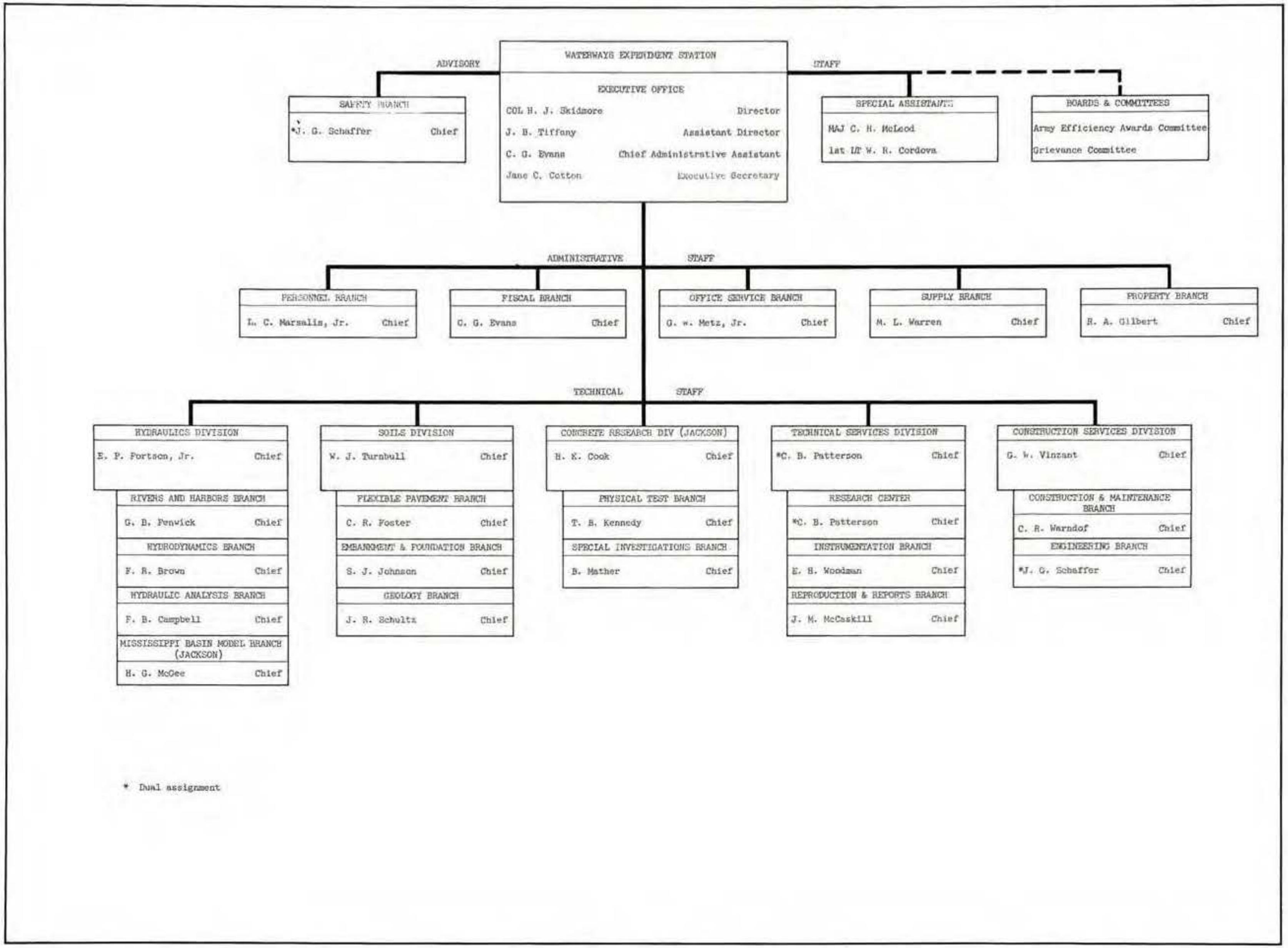

WATERWAYS EXPERIMENT STATION
EXECUTIVE OFFICE
COL H. J. Skidmore Director
J. B. Tiffany Assistant Director
C. G. Evans Administrative Assistant
Jane C. Cotton Executive Secretary
SAFETY BRANCH
*J. G. Schaffer Chief
BOARDS & COMMITTEES
Suggestion Committee
Civilian Awards Committee
Grievance Committee
ADMINISTRATIVE STAFF
PERSONNEL BRANCH
S. S. Rushing Chief
FISCAL BRANCH
R. A. Hough, Jr. Chief
OFFICE SERVICE BRANCH
G. W. Metz, Jr. Chief
SUPPLY BRANCH
M. L. Warren Chief
TECHNICAL STAFF
HYDRAULICS DIVISION
*G. B. Fenwick Chief
HYDRODYNAMICS BRANCH
F. R. Brown Chief
HYDRAULICS ANALYSIS BRANCH
F. B. Campbell Chief
RIVERS AND HARBORS BRANCH
*G. B. Fenwick Chief
MISSISSIPPI RIVER BASIN MODEL BRANCH (JACKSON)
H. C. McGee Chief
SOILS DIVISION
W. J. Turnbull Chief
FLEXIBLE PAVEMENT BRANCH
C. R. Foster Chief
EMBANKMENT & FOUNDATION BRANCH
S. J. Johnson Chief
GEOLOGY BRANCH
J. R. Schultz Chief
CONCRETE RESEARCH DIV (JACKSON)
H. K. Cook Chief
PHYSICAL TEST BRANCH
T. B. Kennedy Chief
SPECIAL INVESTIGATION BRANCH
B. Mather Chief
TECHNICAL SERVICES DIVISION
C. B. Patterson Chief
RESEARCH CENTER
Vacant
INSTRUMENTATION BRANCH
E. H. Woodman Chief
REPRODUCTION & REPORTS BRANCH
J. M. McCaskill Chief
CONSTRUCTION SERVICES DIVISION
G. W. Vinzant Chief
CONSTRUCTION & MAINTENANCE BR
C. R. Warndof Chief
ENGINEERING BRANCH
*J. G. Schaffer Chief
* Dual assignment

1 July 1951



WATERWAYS EXPERIMENT STATION
EXECUTIVE OFFICE
COL H. J. Skidmore Director
J. B. Tiffany Assistant Director
C. G. Evans Chief Administrative Assistant
Jane C. Cotton Executive Secretary
ADVISORY
SAFETY BRANCH
*J. G. Schaffer Chief
STAFF
SPECIAL ASSISTANTS
MAJ C. H. McLeod
1st LT W. R. Cordova
BOARDS & COMMITTEES
Army Efficiency Awards Committee
Grievance Committee
ADMINISTRATIVE STAFF
PERSONNEL BRANCH
L. C. Marsalis, Jr. Chief
FISCAL BRANCH
C. G. Evans Chief
OFFICE SERVICE BRANCH
G. W. Metz, Jr. Chief
SUPPLY BRANCH
M. L. Warren Chief
PROPERTY BRANCH
R. A. Gilbert Chief
TECHNICAL STAFF
HYDRAULICS DIVISION
E. P. Fortson, Jr. Chief
RIVERS AND HARBORS BRANCH
G. B. Fenwick Chief
HYDRODYNAMICS BRANCH
F. R. Brown Chief
HYDRAULIC ANALYSIS BRANCH
F. B. Campbell Chief
MISSISSIPPI BASIN MODEL BRANCH (JACKSON)
H. G. McGee Chief
SOILS DIVISION
W. J. Turnbull Chief
FLEXIBLE PAVEMENT BRANCH
C. R. Foster Chief
EMBANKMENT & FOUNDATION BRANCH
S. J. Johnson Chief
GEOLOGY BRANCH
J. R. Schultz Chief
CONCRETE RESEARCH DIV (JACKSON)
H. K. Cook Chief
PHYSICAL TEST BRANCH
T. B. Kennedy Chief
SPECIAL INVESTIGATIONS BRANCH
B. Mather Chief
TECHNICAL SERVICES DIVISION
*C. B. Patterson Chief
RESEARCH CENTER
*C. B. Patterson Chief
INSTRUMENTATION BRANCH
E. H. Woodman Chief
REPRODUCTION & REPORTS BRANCH
J. M. McCaskill Chief
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G. W. Vinzant Chief
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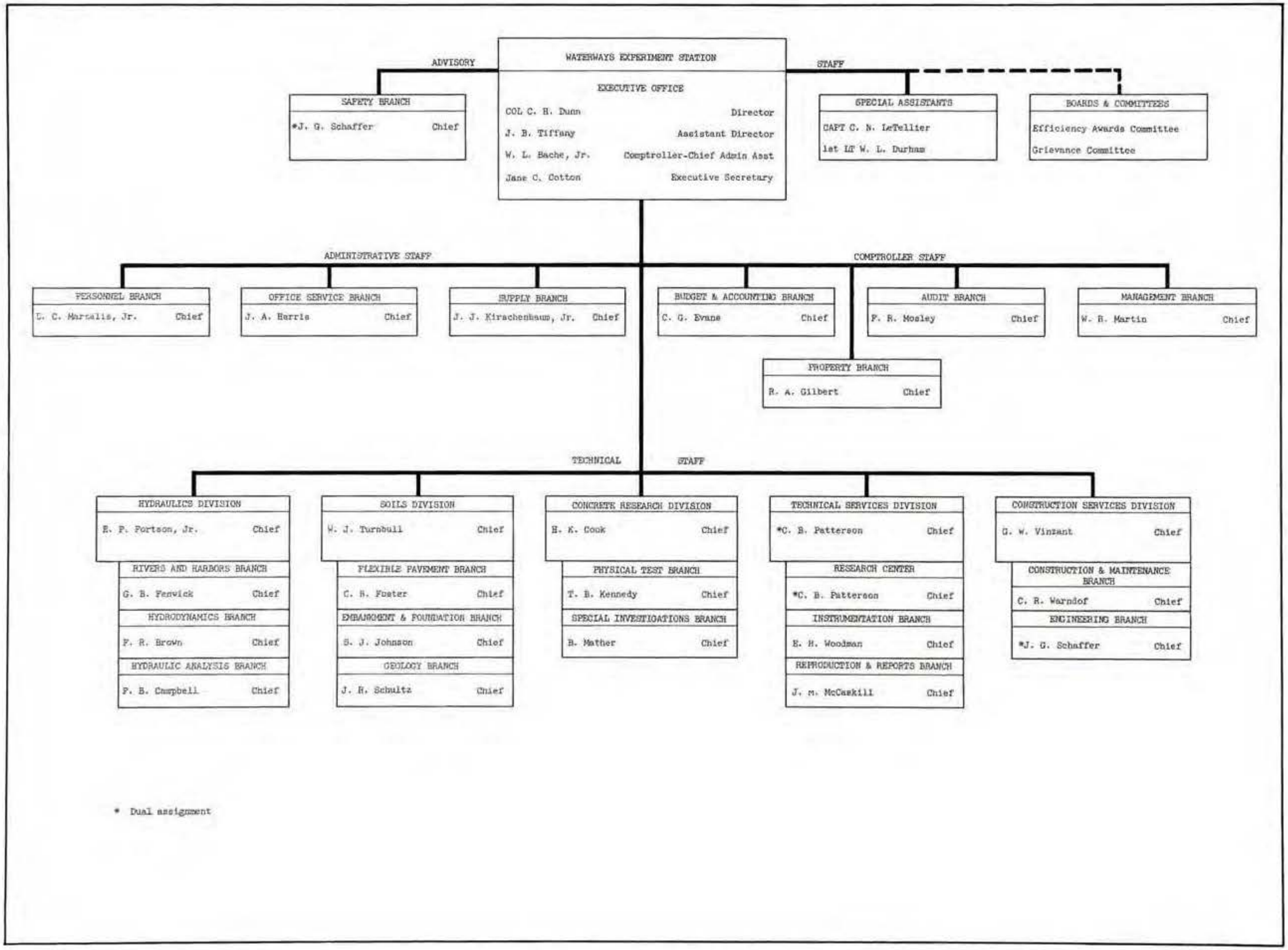
C. R. Warndof Chief
ENGINEERING BRANCH
*J. G. Schaffer Chief
* Dual assignment

1 July 1952



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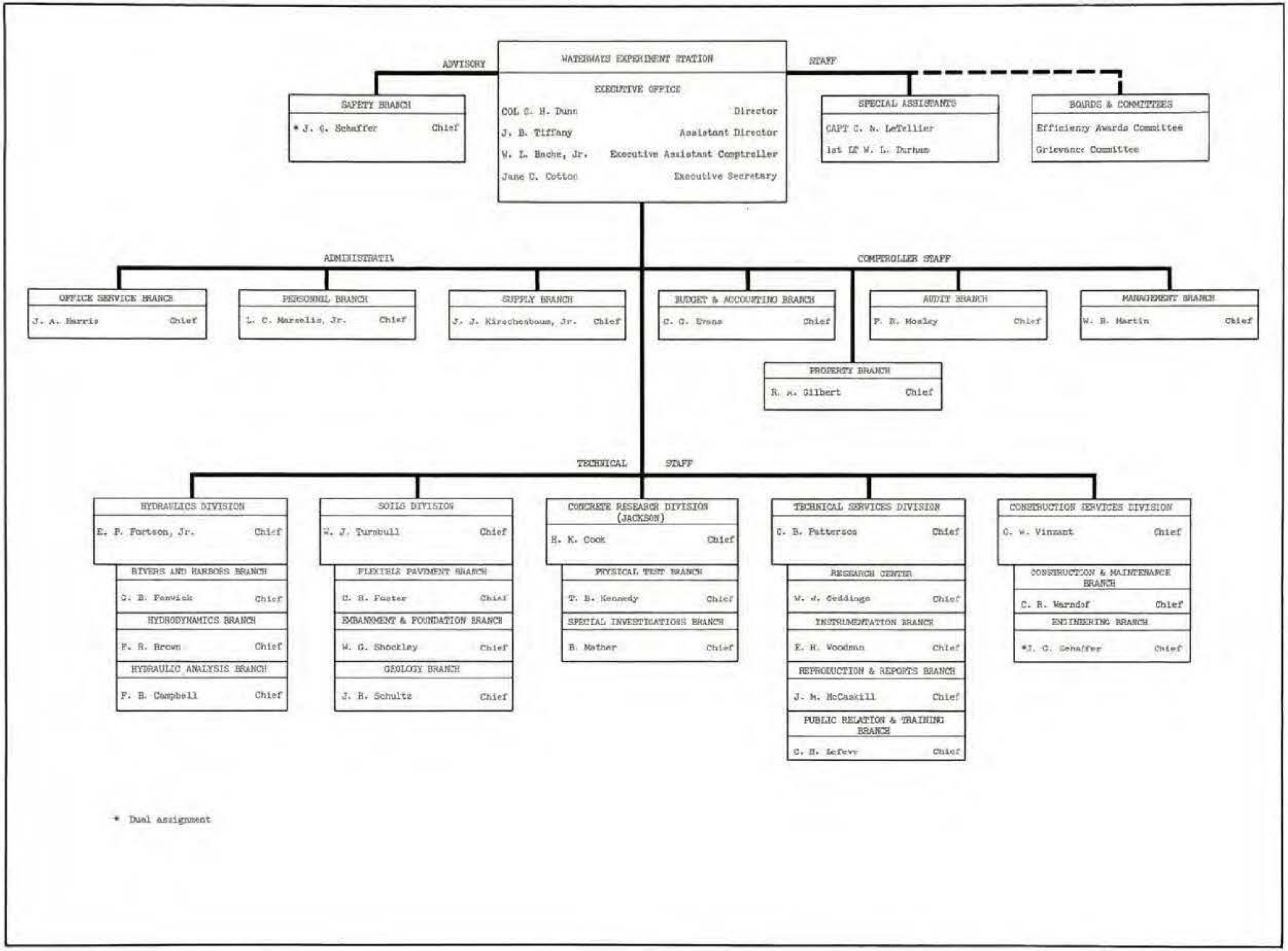
WATERWAYS EXPERIMENT STATION
EXECUTIVE OFFICE
COL C. H. Dunn Director
J. B. Tiffany Assistant Director
W. L. Bache, Jr. Executive Assistant Comptroller
Jane C. Cotton Executive Secretary
ADVISORY
SAFETY BRANCH
* J. G. Schaffer Chief
STAFF
SPECIAL ASSISTANTS
CAPT C. N. LeTellier
1st LT W. L. Durham
BOARDS & COMMITTEES
Efficiency Awards Committee
Grievance Committee
ADMINISTRATIV
OFFICE SERVICE BRANCH
J. A. Harris Chief
PERSONNEL BRANCH
L. C. Marcelis, Jr. Chief
SUPPLY BRANCH
J. J. Kirschenbaum, Jr. Chief
COMPTROLLER STAFF
BUDGET & ACCOUNTING BRANCH
C. G. Evans Chief
AUDIT BRANCH
P. R. Mosley Chief
MANAGEMENT BRANCH
W. B. Martin Chief
PROPERTY BRANCH
R. A. Gilbert Chief
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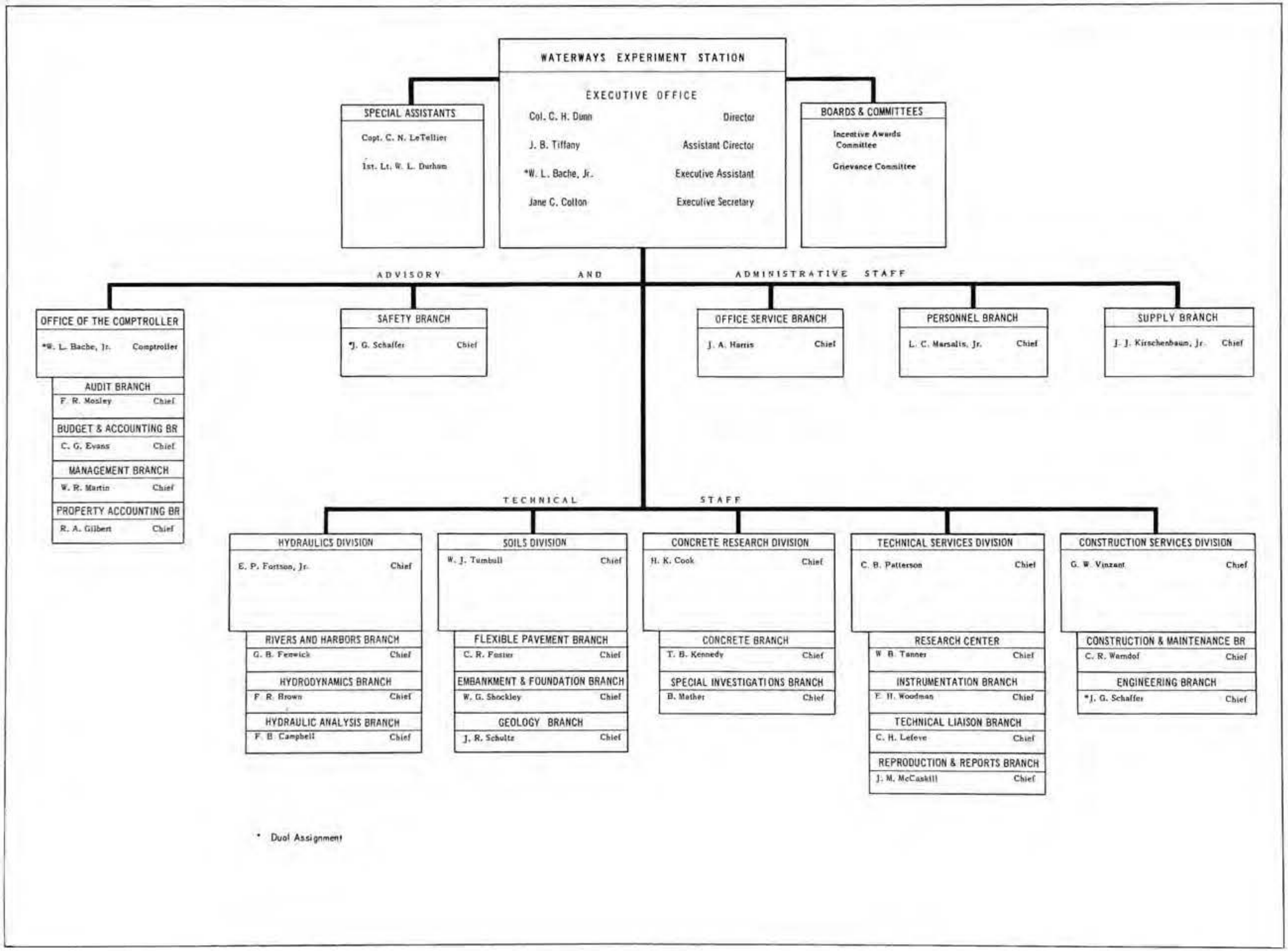
HYDRAULICS DIVISION
E. P. Fortson, Jr. Chief
RIVERS AND HARBORS BRANCH
C. B. Fenwick Chief
HYDRODYNAMICS BRANCH
F. R. Brown Chief
HYDRAULIC ANALYSIS BRANCH
F. B. Campbell Chief
SOILS DIVISION
W. J. Turnbull Chief
FLEXIBLE PAVEMENT BRANCH
C. R. Foster Chief
EMBANKMENT & FOUNDATION BRANCH
W. G. Shockley Chief
GEOLOGY BRANCH
J. R. Schultz Chief
CONCRETE RESEARCH DIVISION (JACKSON)
H. K. Cook Chief
PHYSICAL TEST BRANCH
T. B. Kennedy Chief
SPECIAL INVESTIGATIONS BRANCH
B. Mather Chief
TECHNICAL SERVICES DIVISION
C. B. Patterson Chief
RESEARCH CENTER
W. J. Geddings Chief
INSTRUMENTATION BRANCH
E. H. Woodman Chief
REPRODUCTION & REPORTS BRANCH
J. M. McCaskill Chief
PUBLIC RELATION & TRAINING BRANCH
C. H. Lefevre Chief
CONSTRUCTION SERVICES DIVISION
C. W. Vinzant Chief
CONSTRUCTION & MAINTENANCE BRANCH
C. R. Warndof Chief
ENGINEERING BRANCH
*J. G. Schaffer Chief
* Dual assignment

1 July 1953



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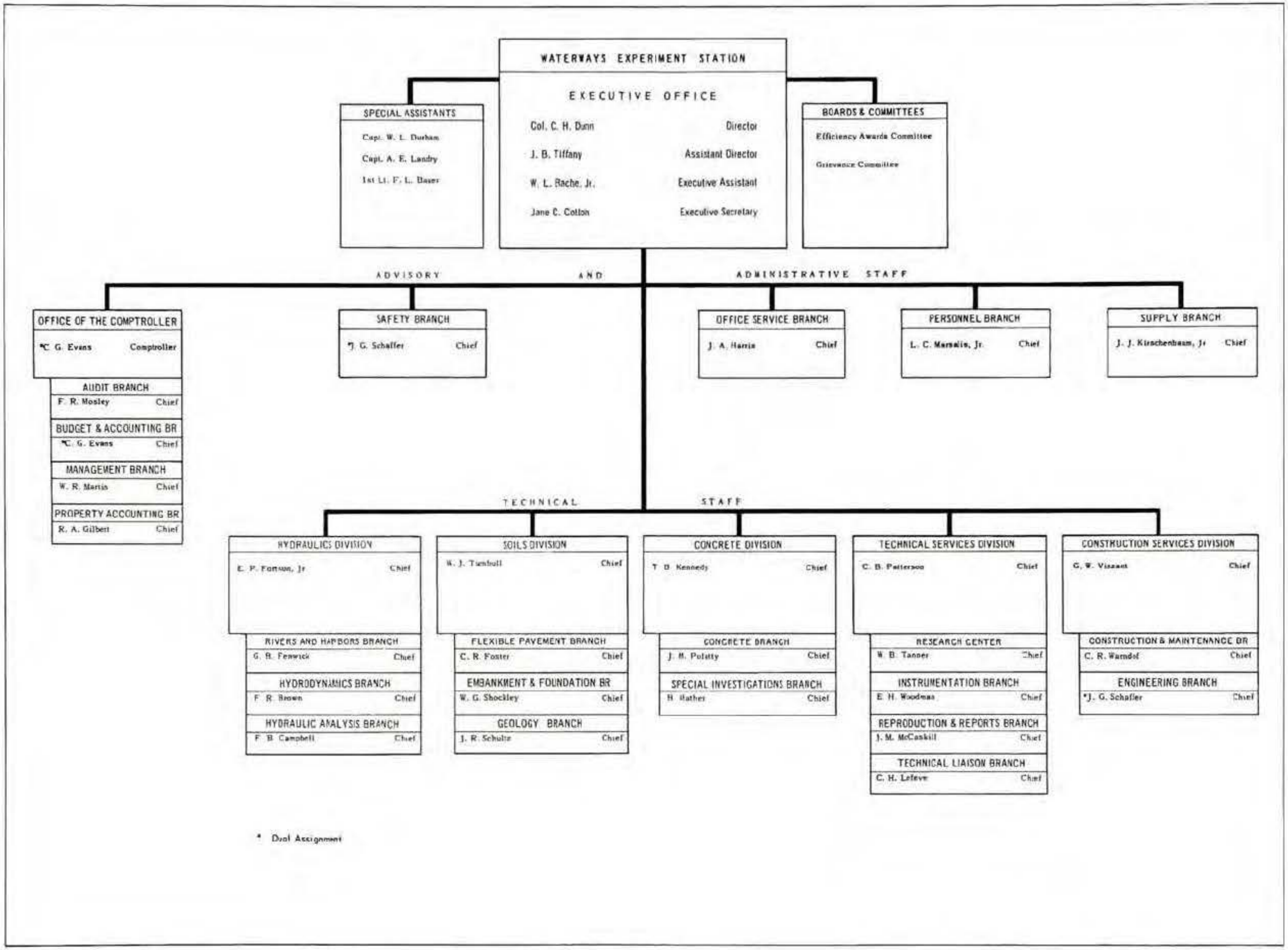

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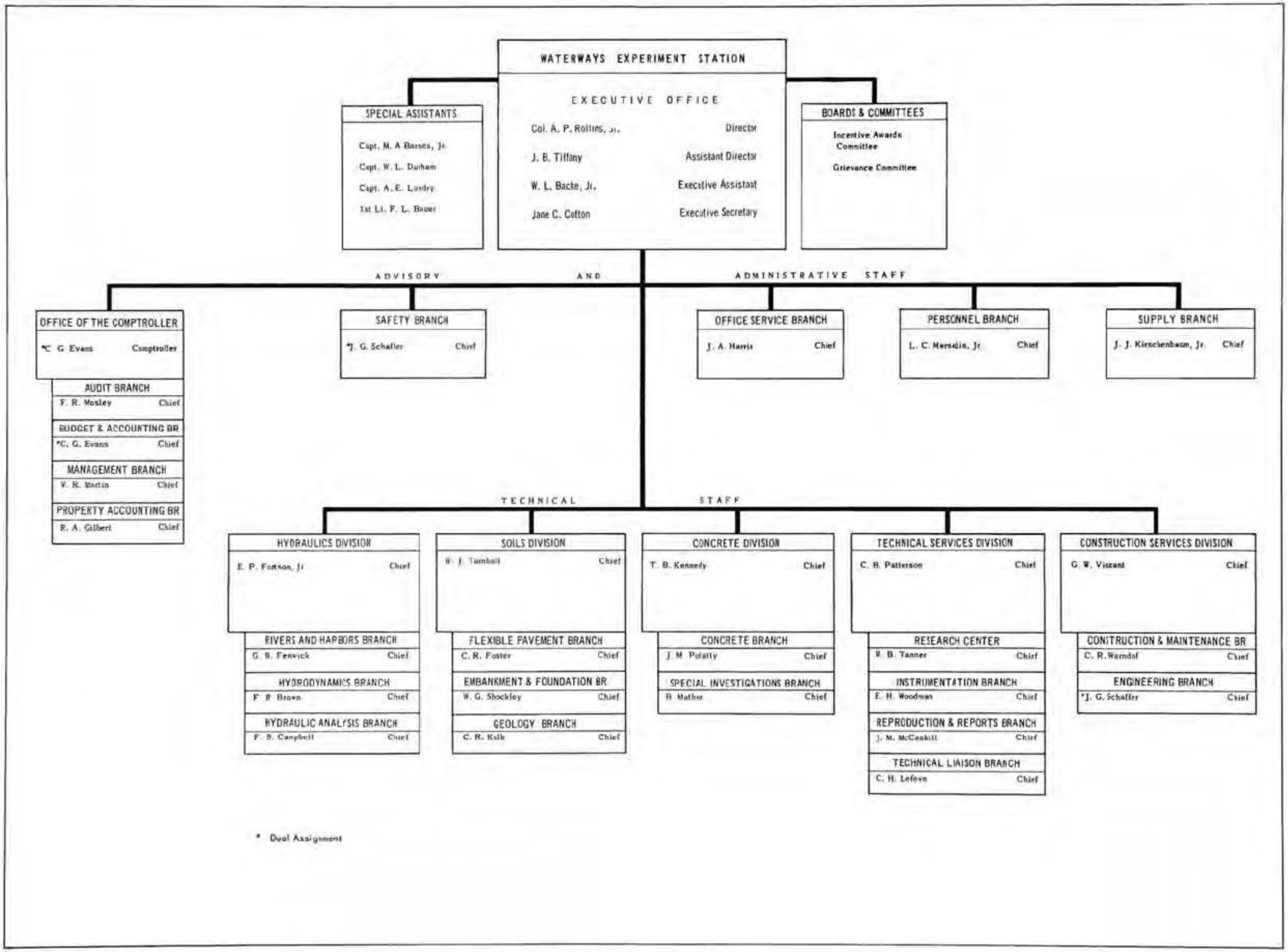
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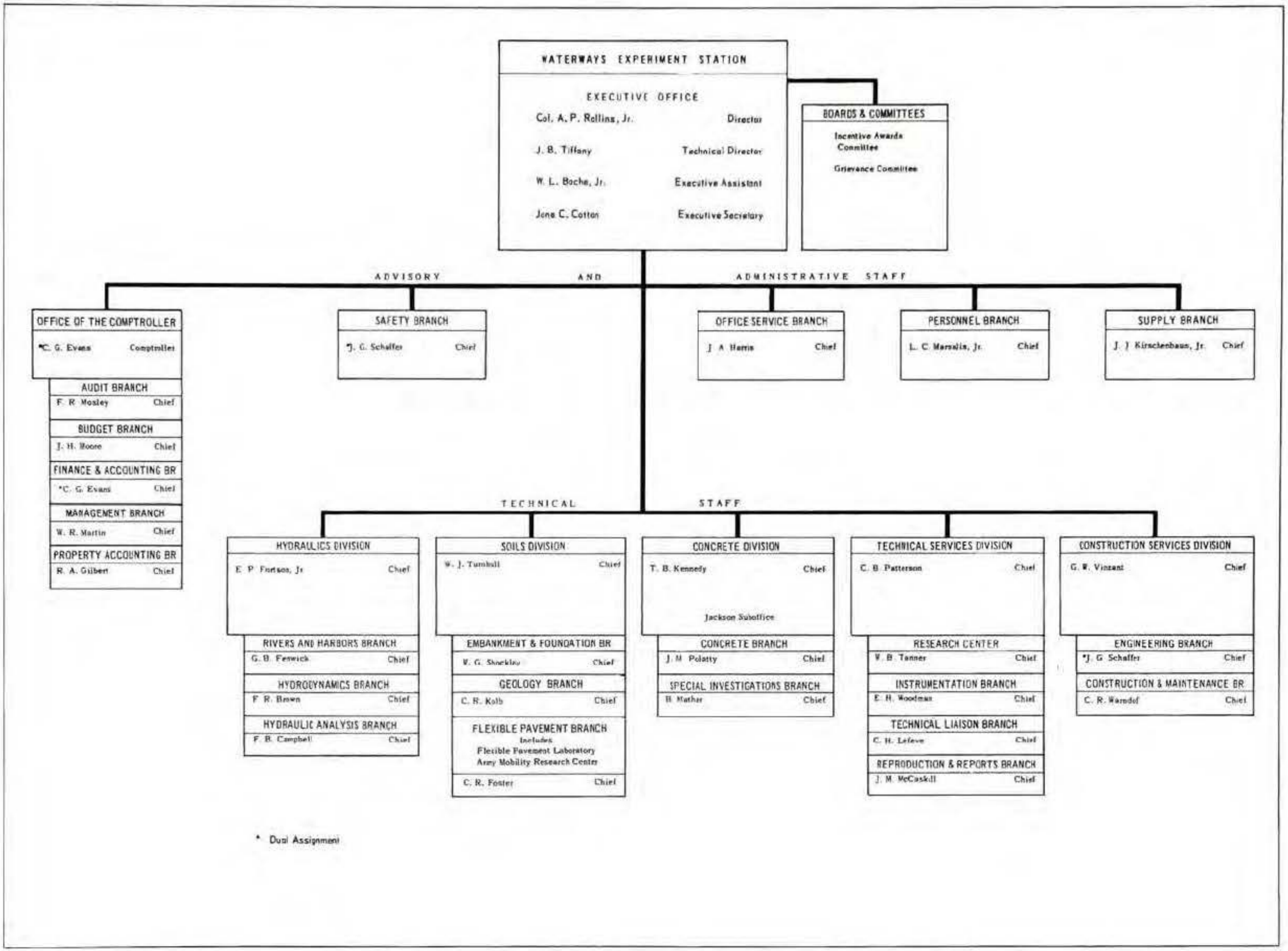

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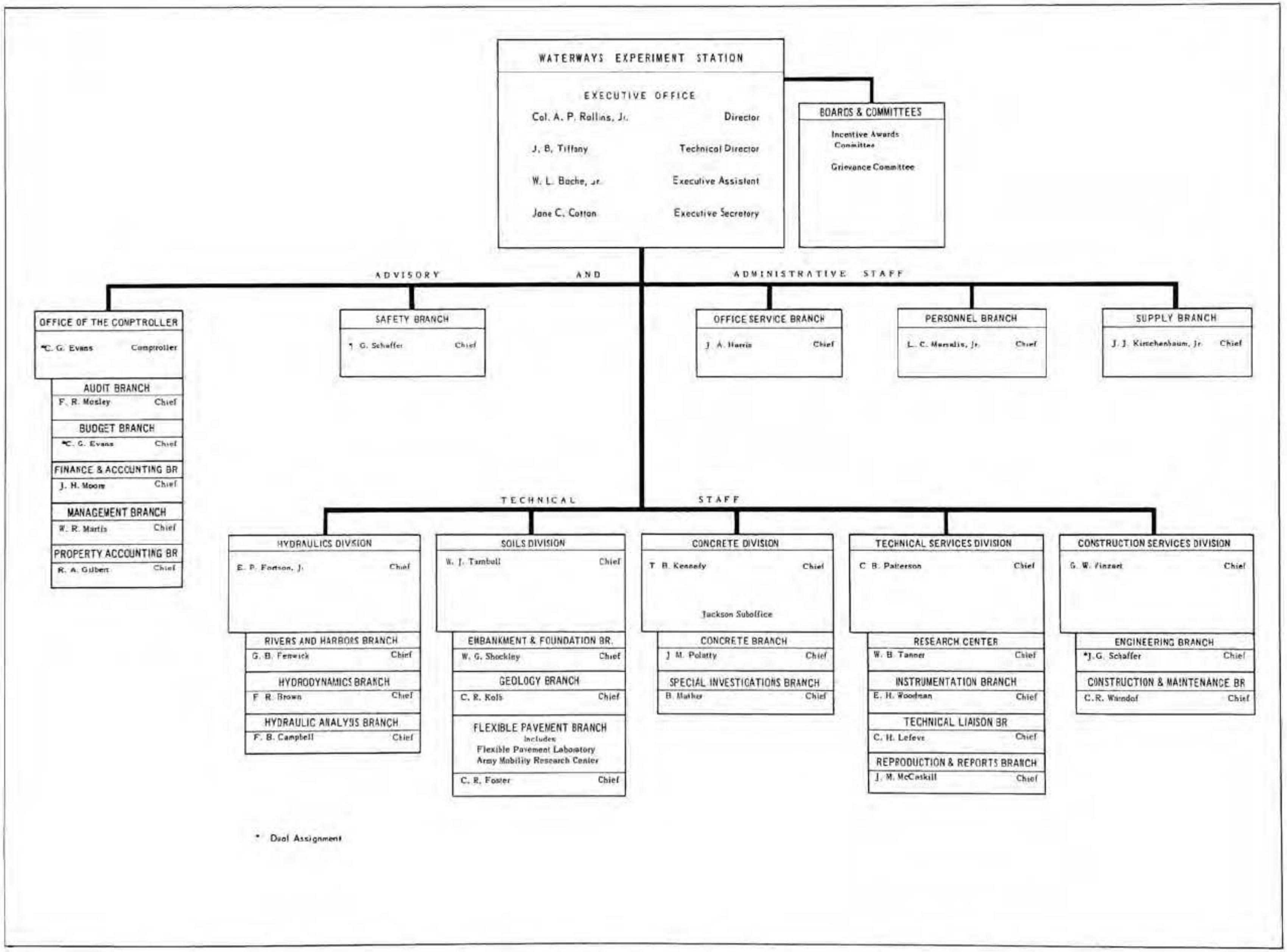
1 July 1956



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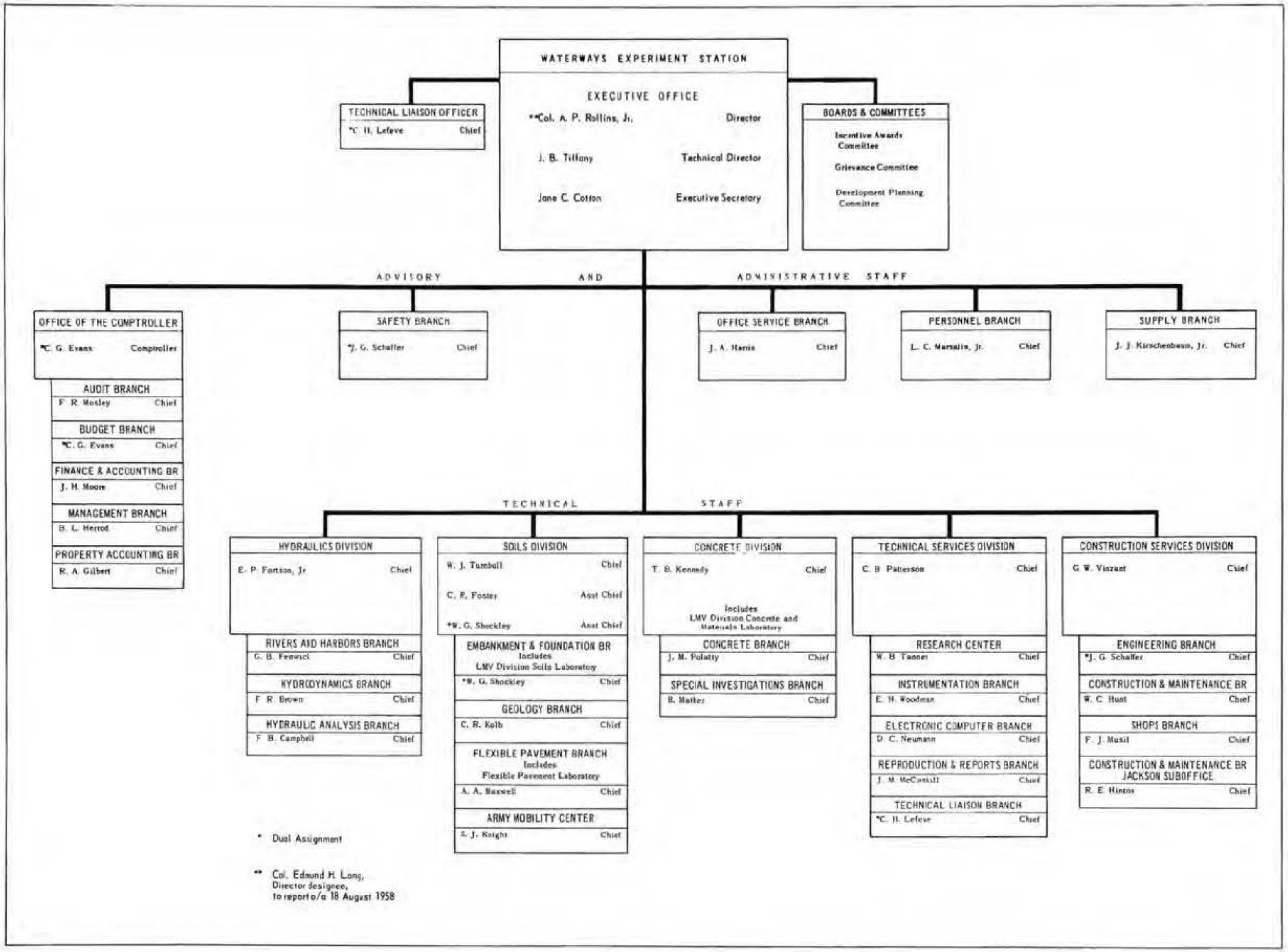
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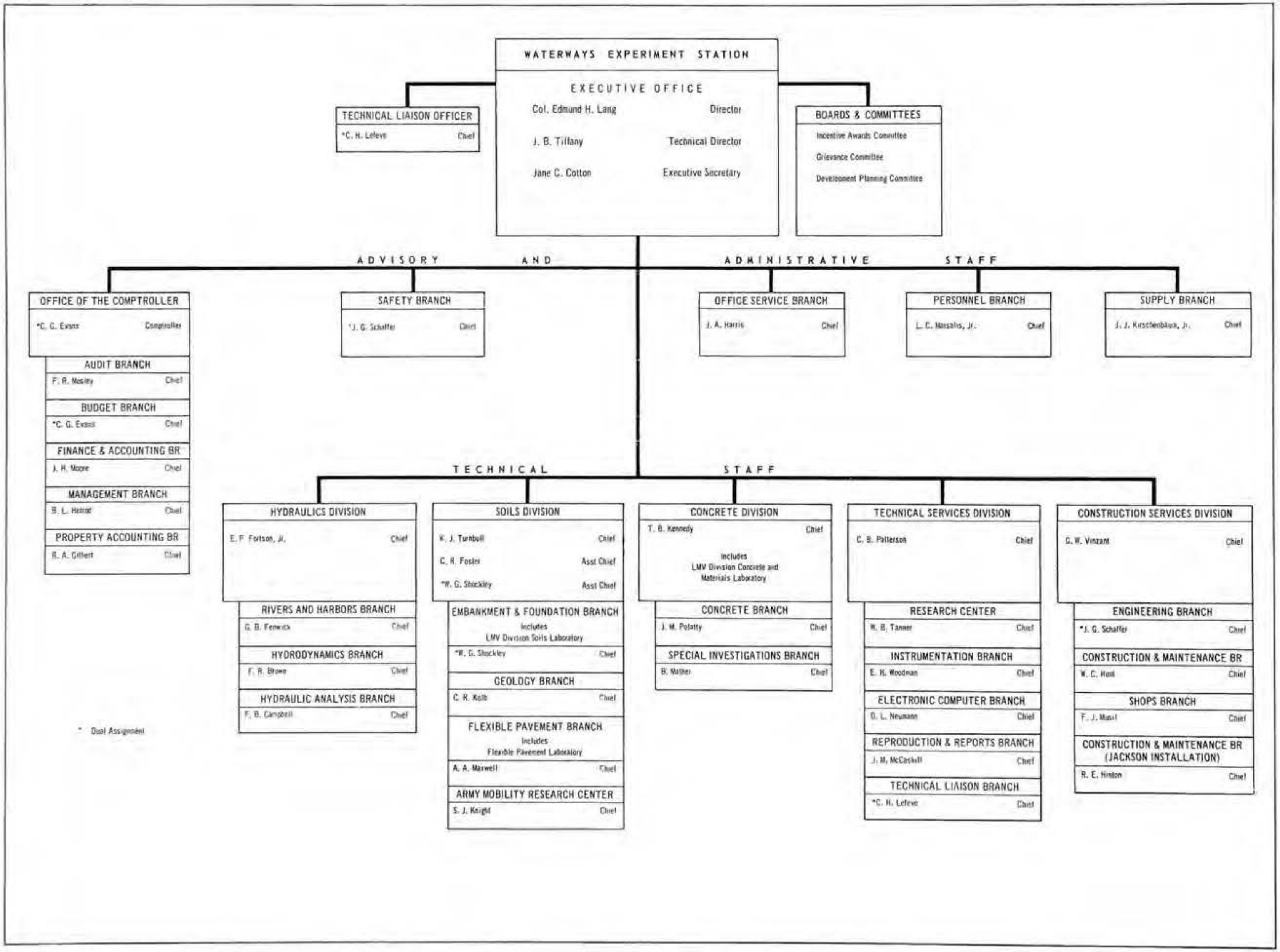
R. E. Hinton Chief
* Dual Assignment
** Col. Edmund H. Long, Director designee, to report o/a 18 August 1958

1 July 1958



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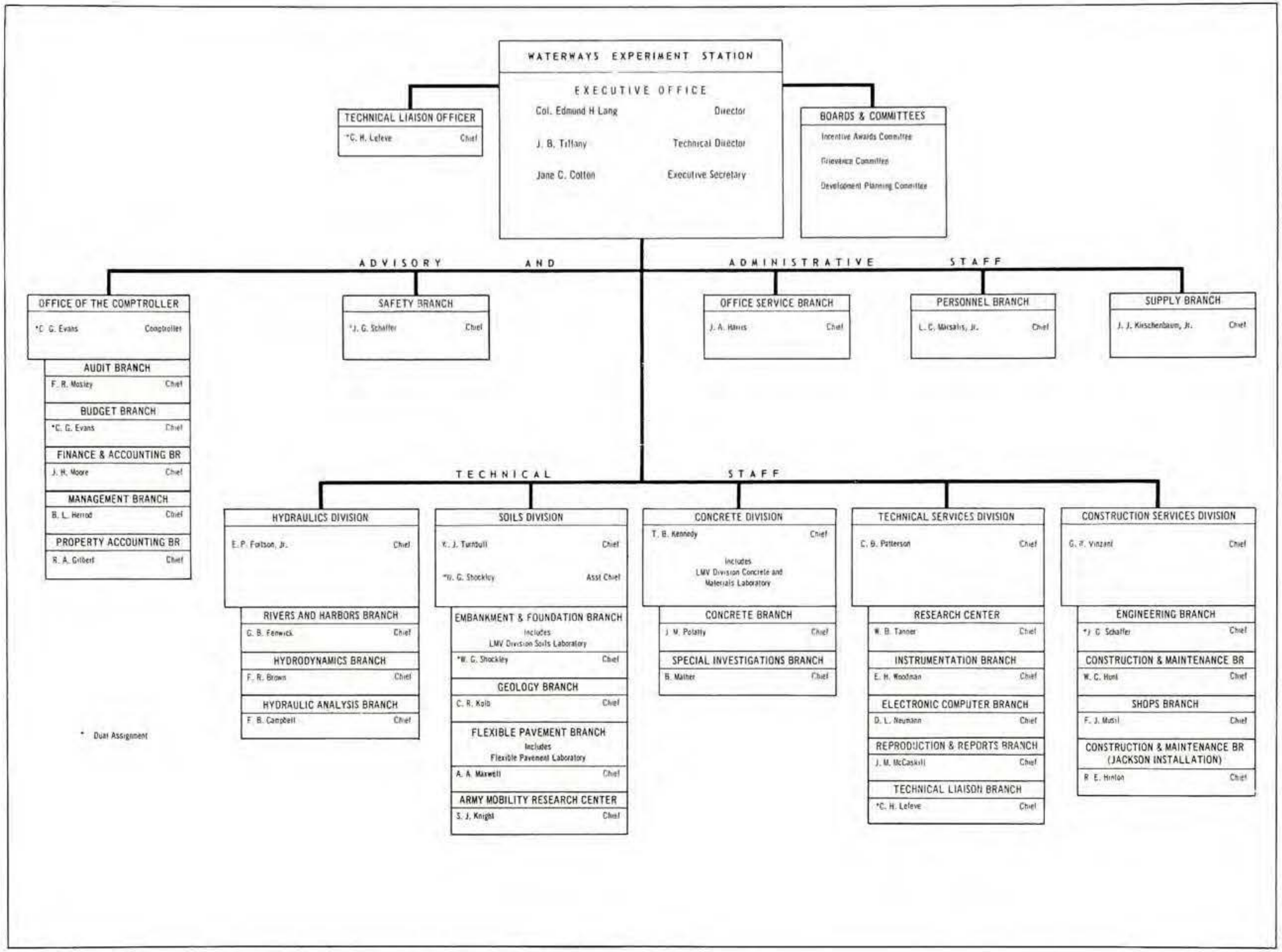

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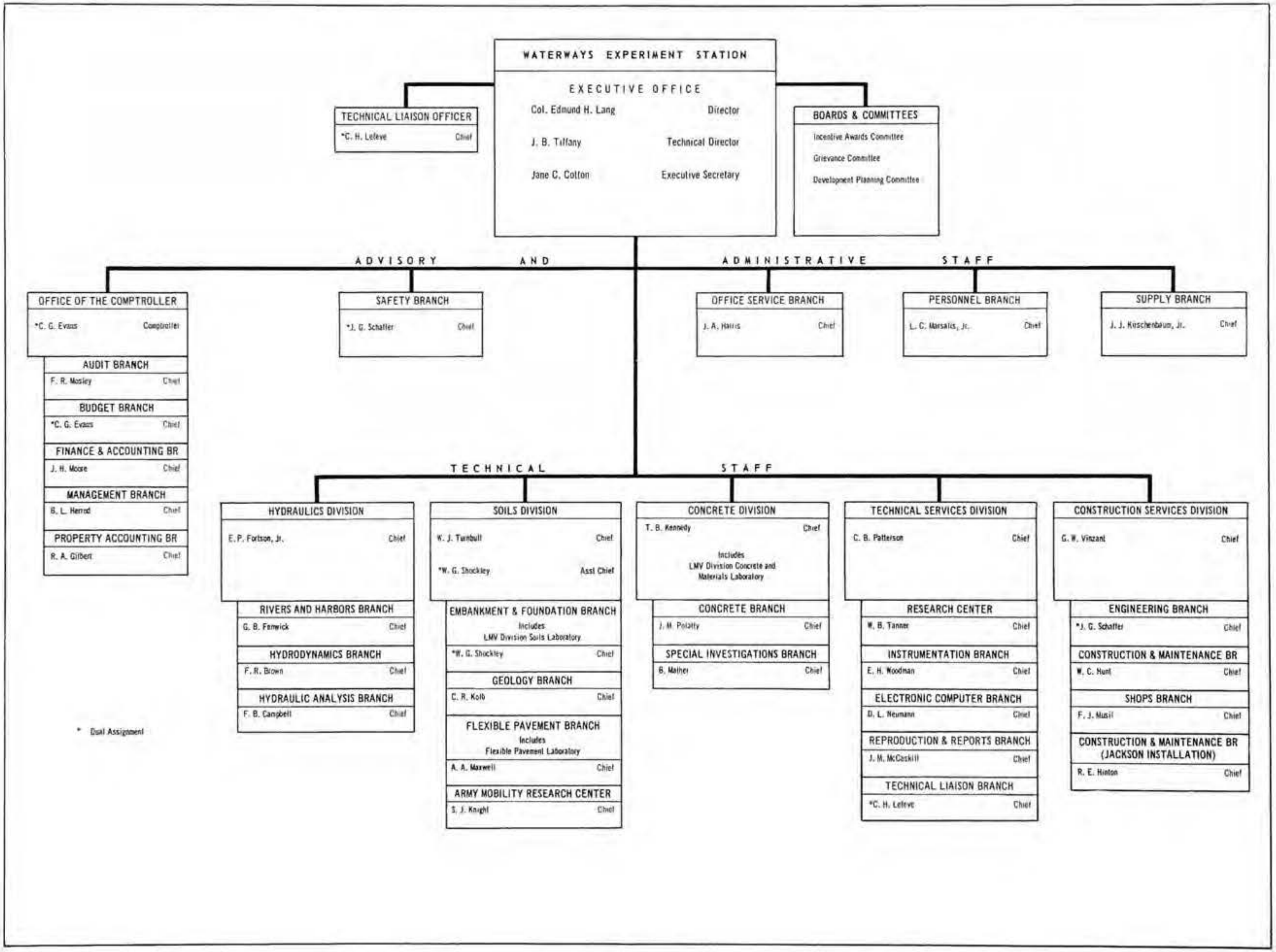
15 May 1959



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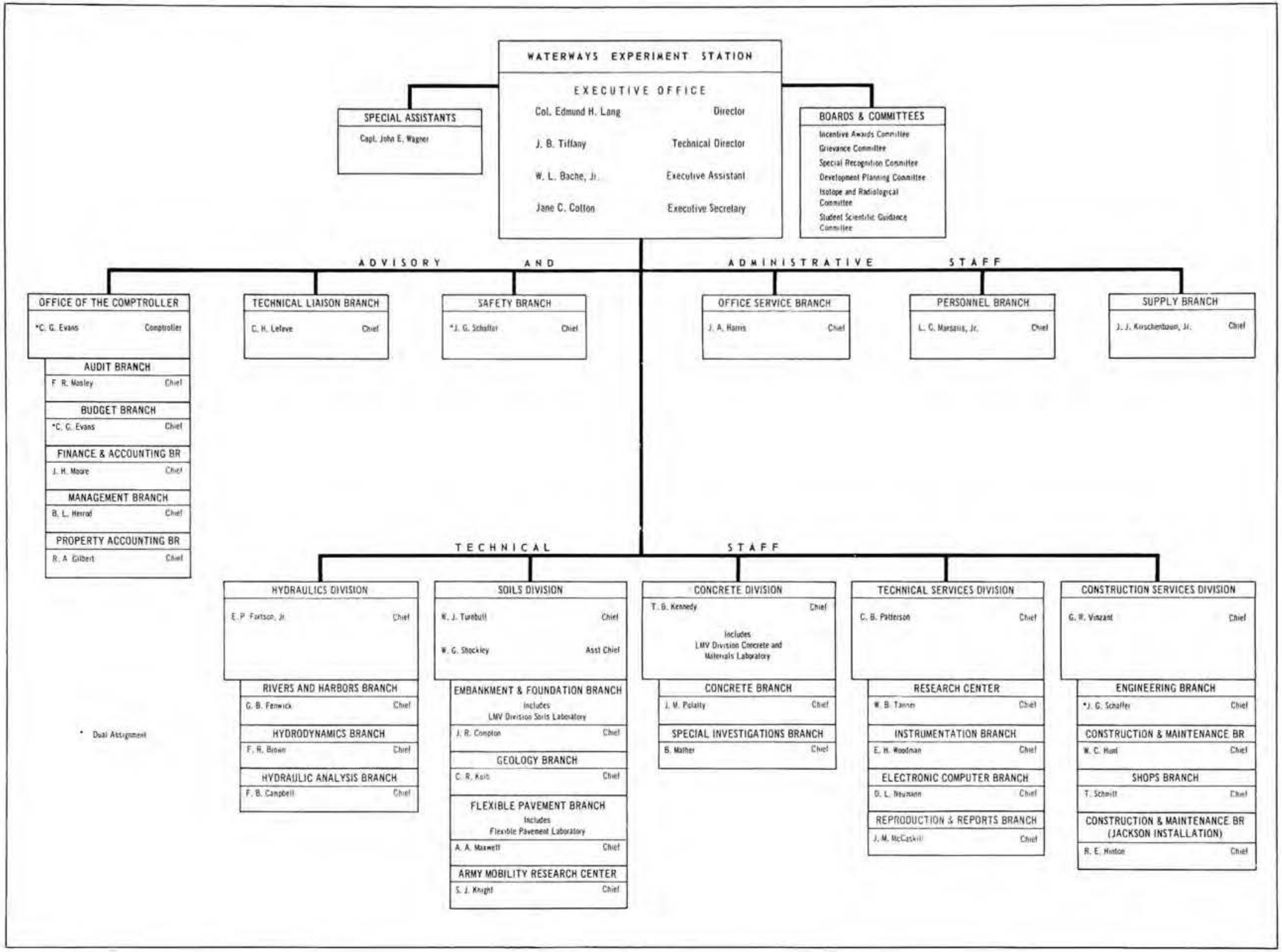

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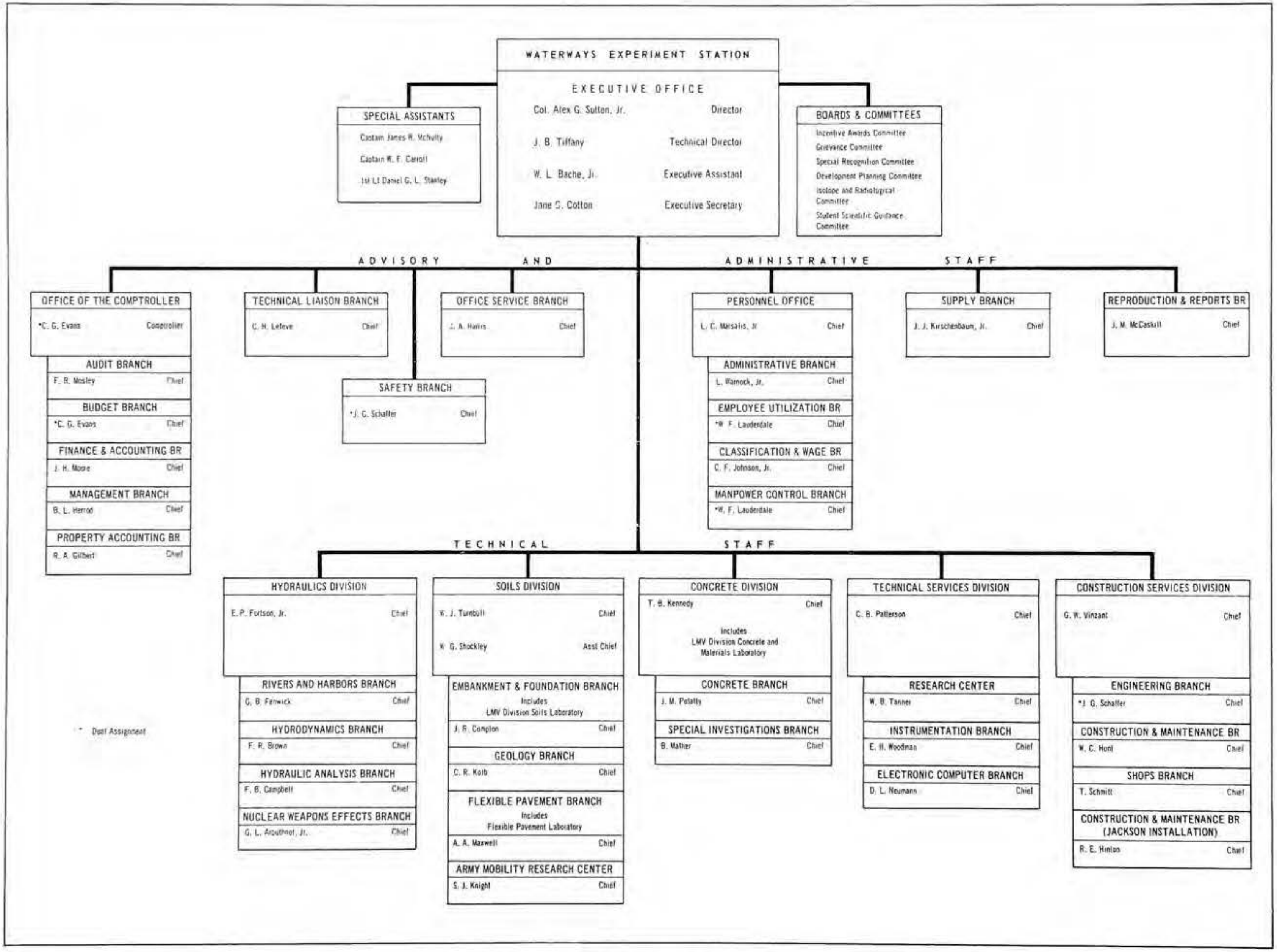

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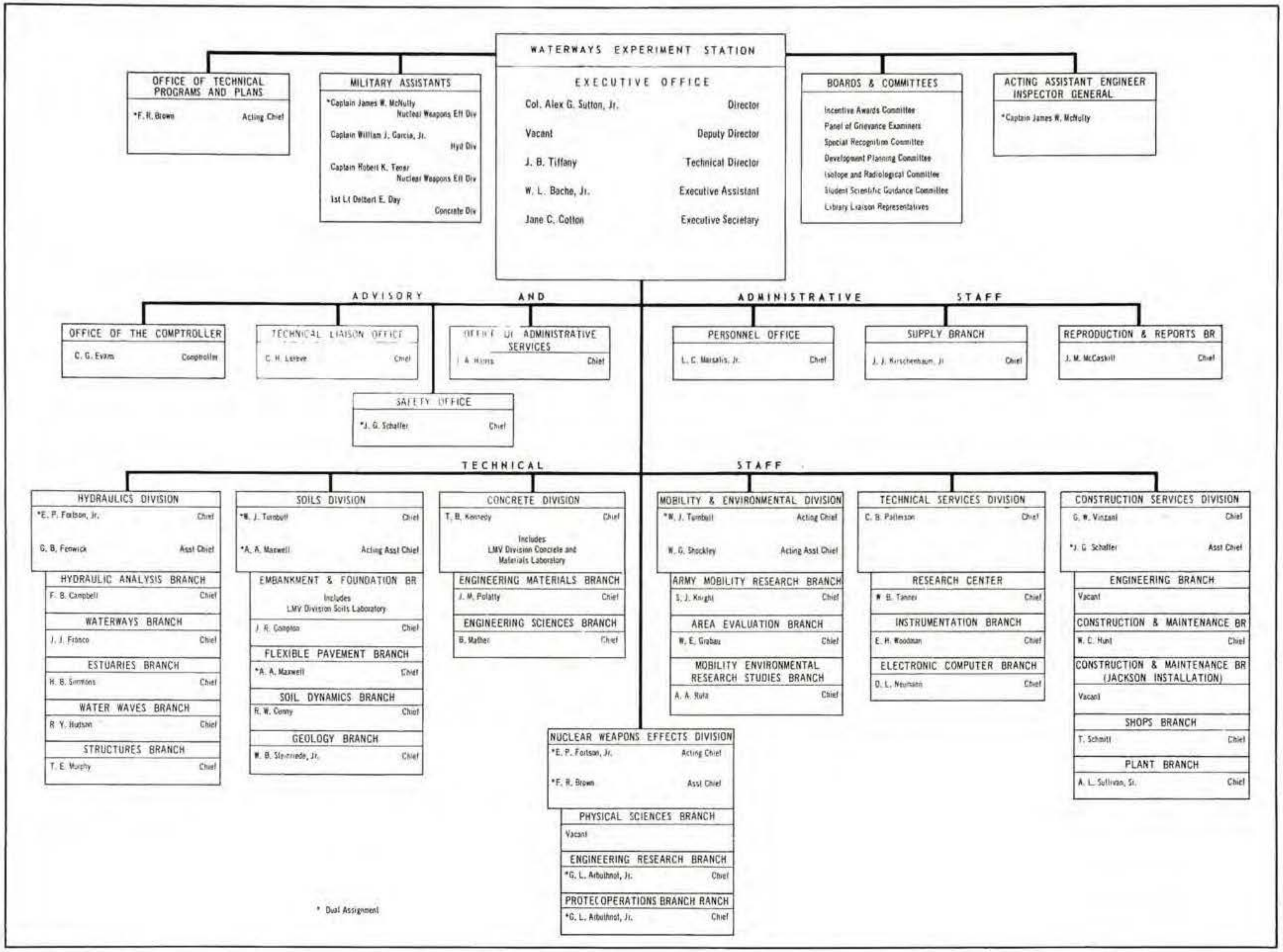

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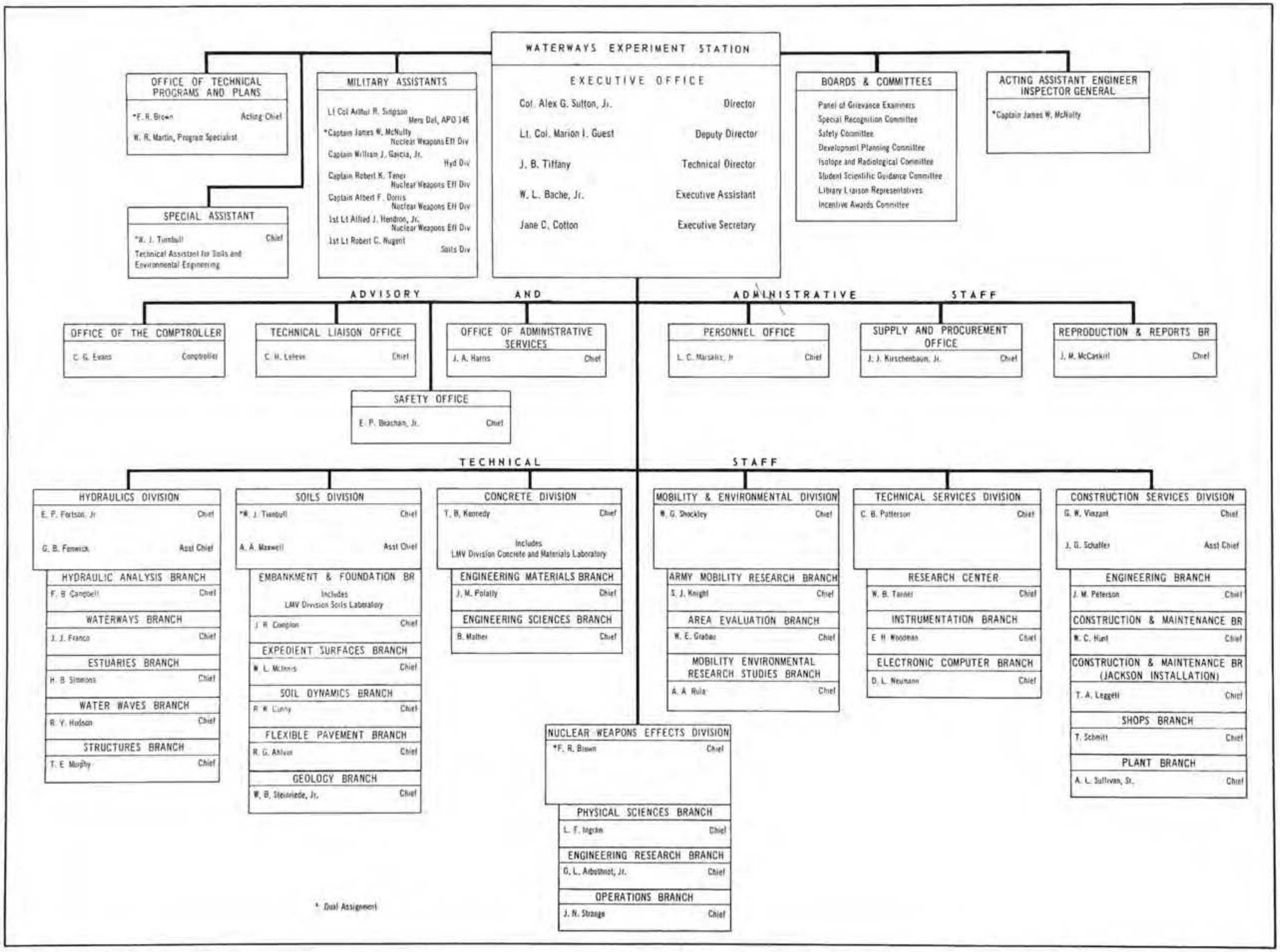

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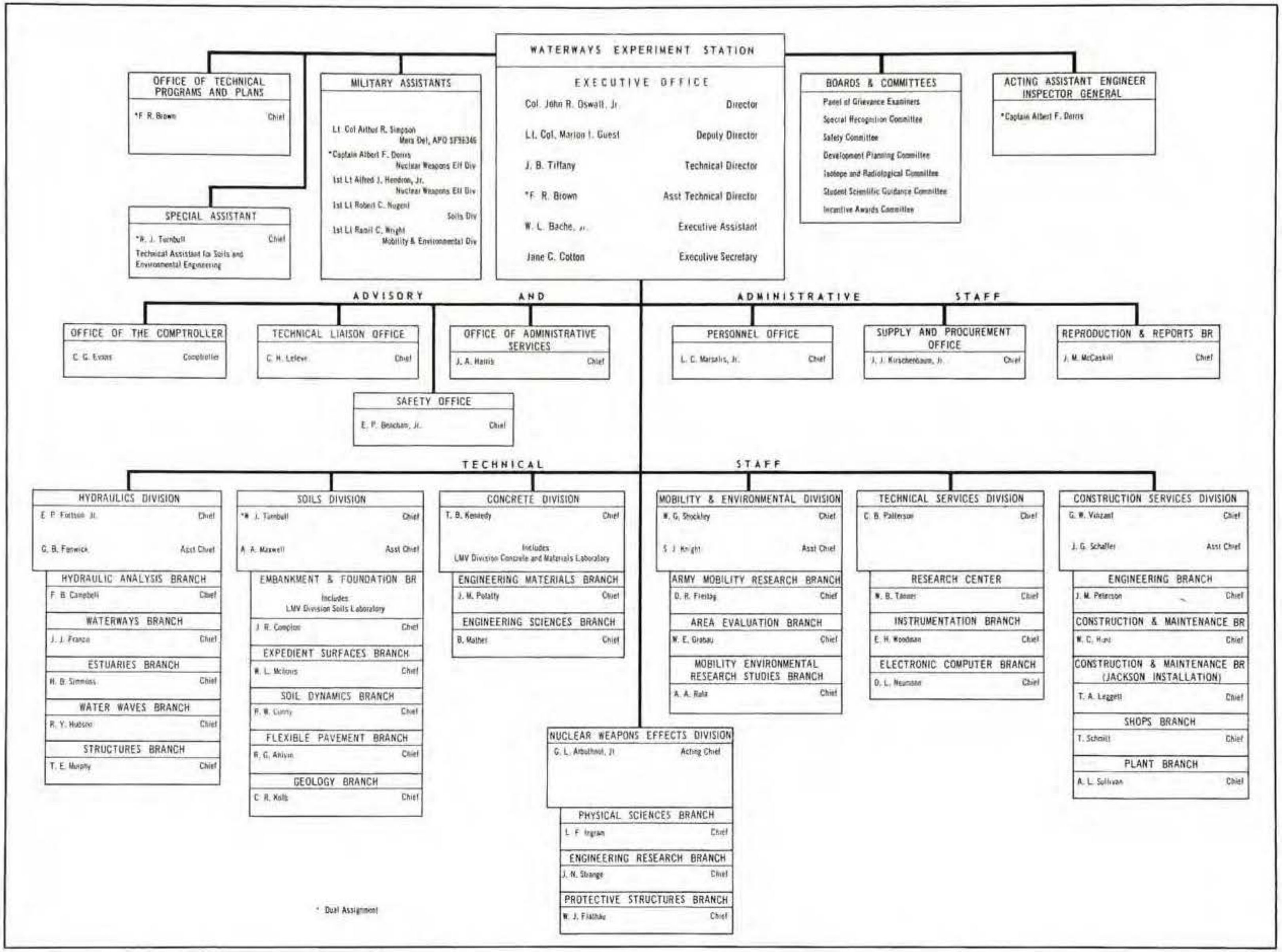

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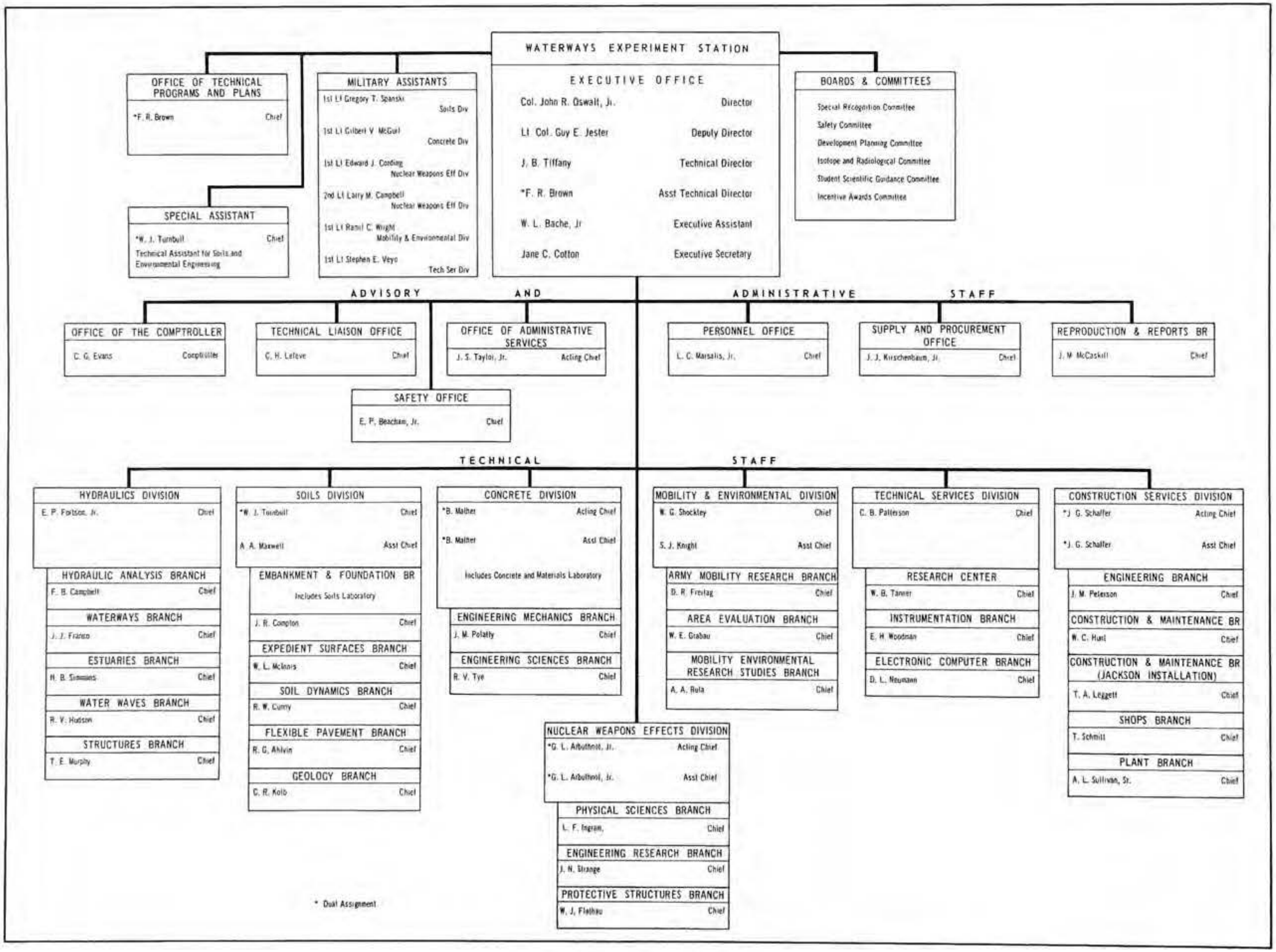

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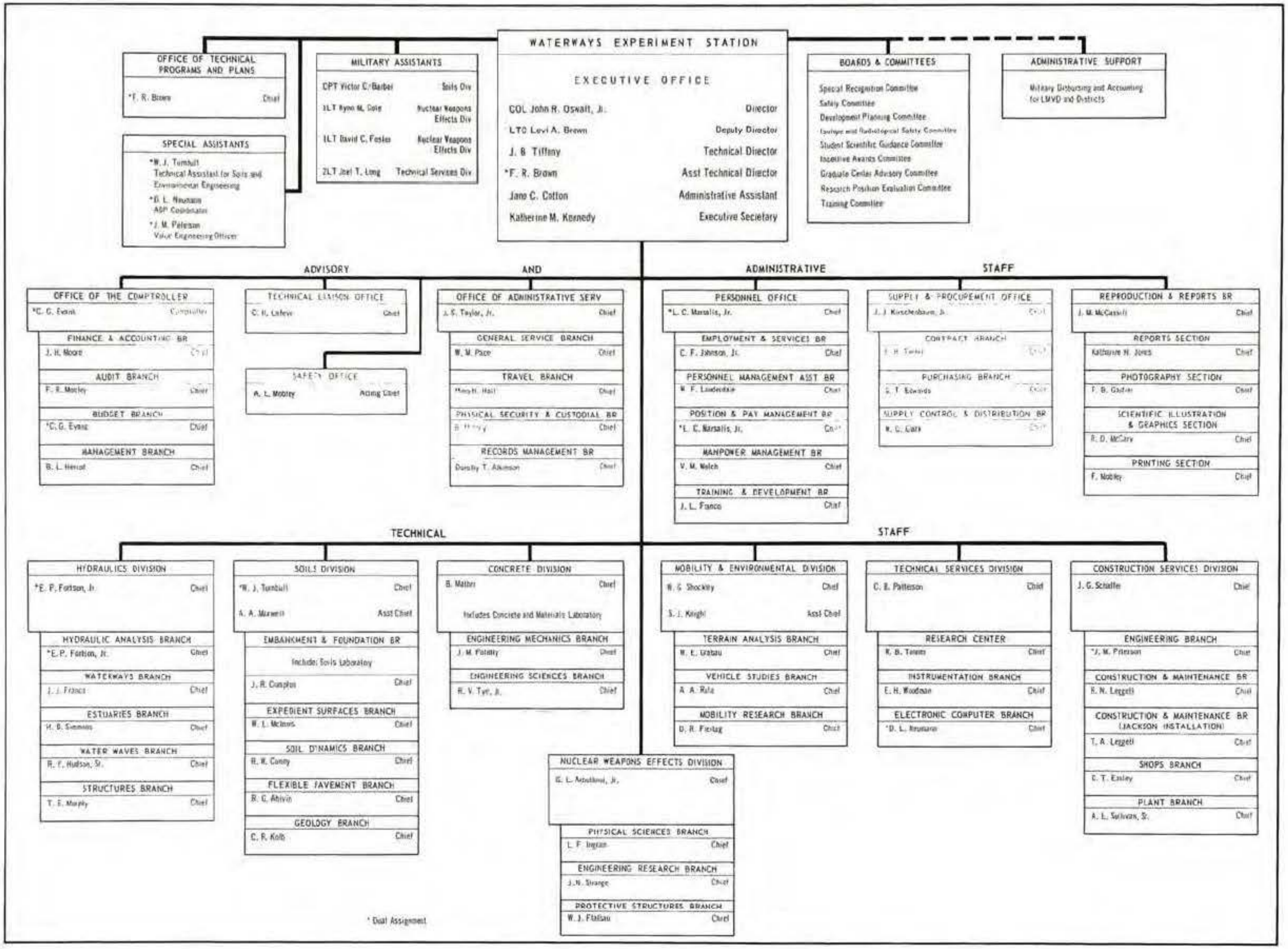

22 August 1967

Appendix IV
COMMENTS OF FORMER DIRECTORS

Comments prepared by former Directors of the WES concerning what each considered to be the principal problems, major changes effected, and major accomplishments during their respective tours, with the exception of those by BG H. D. Vogel, first Director, are presented in this appendix. The story of the origin of the WES as told by GEN Vogel is contained in Appendix I. As noted in the main text, two former Directors--1LT Francis H. Falkner and Mr. Gerard H. Matthes--are deceased. Additional comments have been promised by COL E. H. Lang for inclusion at a later date.

CPT Paul W. Thompson
July 1937-Sept 1939

Engineering is a science (leavened with touches of art); and the pursuit of Engineering through simulation on a small scale of forces aiding in the solution of practical problems is a high manifestation of the Engineering science. But reminiscing about experiences in Engineering is a nonprecise exercise in nostalgia. Reflecting on my tenure as Director of the U. S. Waterways Experiment Station, I'm engaging in an exercise in nostalgia.

The very names--names of projects on which we worked--stir in me feelings warm and nostalgic: Starved Rock Lock, St. Lucie Canal, Atchafalaya Spillway, Old River and Head of Passes, Maracaibo Bar, Johnstown Flood Control, Diamond Point Cutoff, Galveston Channel...... I can't recall--I'm not attempting to recall--just what it was we tried to do (and usually succeeded in doing) in each of those studies. But the names! And the (nonprecise) memories!

GEN Vogel is describing on another page the genesis of the Waterways Experiment Station (whatever happened to the "U. S." part of the title?). The Experiment Station was born under a Happy Star--and one of the happiest things about it was the person of its founding Director: the then 1LT Herbert D. Vogel. Vog possessed in rarest combination (so rare I've never since encountered the like) the qualities of technical knowledge, enthusiasm, and ability to persuade and convince--qualities which were essential to getting the Experiment Station established on a sound basis, and getting it accepted both in the realms of academic science, and in the councils of the hardheaded District and Division Engineers from whom the commissions for projects to be accomplished would have to come.

What a fellow, that Herbert D. Vogel. I'll call on memory for a scene typical of those early Experiment Station days: In the living room of Vog's home, that impressive house overlooking the dam and lake; the turntable of Vog's phonograph converted to a carrier for a beaker of water; in the water a spoonful of oat grains (as I recall it, oat grains had just the right specific gravity; they tended to sink to the bottom, but just barely, and like arrows they pointed out the directions of the slightest currents); Vog and the rest of us observing the effects of centrifugal force on bottom currents as revealed by the oat grains at the bottom of the circling beaker of water; and Vog drawing parallels with what must be happening at the bottom of those Mississippi River bends. Later our conversation would have drifted (rather, been nudged by Vog) to other subjects, maybe to the gathering sentiment for cutting the bends of the Mississippi (shades of Humphrey and Abbott!), maybe to the menace of New-Deal schemes like that shadowy Tennessee Valley Authority (shades of Vog's later career!), and certainly to ways and means of ensuring the survival and prosperity of the Experiment Station.

In due course Frank Falkner succeeded Vog in the Directorship (Vog going on to other great accomplishments--including his brilliant Chairmanship of the TVA), and gave the Experiment Station another strong term of stewardship. Succeeding Frank in 1937, I stepped into a going concern, by then known and respected throughout the engineering world, with a record of delivering satisfaction to scores of clients in the past, and with enough prospective clients lined up ahead to justify optimism. Incidentally, "optimism" is a word which keeps recurring as I pursue this exercise in nostalgia. Optimism--and that Happy Star--and those Names!

Although from the beginning the Experiment Station served the Corps of Engineers at large, in my day the Director of the Station reported to the President of the Mississippi River Commission (a Presidency more significant, by my scales of value of that day, than the Presidency of the U. S. A.); and in my case that meant reporting to BG Harley B. Ferguson. Fergy has ever since remained my own most unforgettable character. Whimsical and picturesque and not very precise in conveying instructions, impatient of experimental results which failed to fit his own instinctive conclusions--but a man of moral courage unsurpassed (yes, unequaled), a man whose "instinctive conclusions" were so often and so uncannily right--especially when the stakes were high. Fergy, the man who cut the bends of the Mississippi--I see him now on that misty morning when the plug was blown and the water surged through at Diamond Point, the first of the man-planned cutoffs. And I like to think that the model studies at the Experiment Station played an important part--more important than Fergy ever admitted or perhaps ever realized--in confirming him in his instinctive conviction that river-straightening would have all the advantages postulated (including arresting and deflating the skyrocketing costs of bank revetments), and would not have the disastrous consequences foreseen by so many for so long (such as accelerated flood waves sweeping down on New Orleans).

Born under a Happy Star--I wonder if another of the happier things about the founding of the Experiment Station was not the concept of charging the costs of a given project to the Division or District benefiting from the work. In effect, this was applying the free-enterprise system to intraservice governmental operations.

It's hard to think of any governmental body other than the Corps of Engineers coming up with such a concept. From the beginning, therefore, the Experiment Station has had to sell its wares to prospective (and hardheaded) buyers--and after making the sale, has had to deliver satisfaction. Incidentally, thinking of satisfaction delivered on so many projects over so many years, it's interesting to speculate (as I used to do even those 30 years ago) on the benefits which must have accrued to our country simply as a result of better and more efficient design of engineering works through data deriving from Experiment Station studies. In my day, I conjectured in terms of tens of millions of dollars; now it would have to be hundreds of millions, maybe billions.

Obviously the Experiment Station has delivered satisfaction to its paying clients; otherwise, it would not still exist, and certainly would not have grown to its present size and stature. I'm moved to reflect on the reasons for this history of solid and sustained success, and here are some of the points which occur to me:

> Honesty in dealing with clients, including prospective clients: never claiming more than can be delivered;
>
> Undeterred by difficulties even by near-impossibilities: where perfection in simulation is not possible (one still can't simulate cavitation, can he?), proceeding on a let's-do-the-best-possible basis--for example, proceeding with a 10-to-1, even a 20-to-1 "distortion" of horizontal-versus-vertical scale ratios where it's either that or no model study at all;
>
> Boldness in developing new working concepts, whether or not supportable in pure theory, as for example the practice of adjusting (do you still call it "verifying"?) a model so that it reproduces accurately known phenomena, and therefore can reasonably be expected to reflect with acceptable accuracy the results of proposed new works;
>
> Skill and ingenuity in surmounting practical problems of procedure, as with mechanical devices for generating waves and tidal flows;
>
> Always, that close and professional contact with the paying partner to the contract, the Office for which the study is being made;
>
> From the beginning, the realization that excellent facilities must be attended by professionally competent and dedicated <u>people</u>.

That last is the most significant point of all--professionally competent and dedicated people. Joe Tiffany--and I endorse all the laudatory things GEN Vogel has to say on another page about Joe--Joe, in asking me for these reminiscences, thoughtfully sent along a few issues of a little brochure we used to get out in my day as Director, called "The Experiment Station Bulletin." Brochures full of those Names! But in "Vol 1 No. 2" of the series, an issue dated October 1, 1938, I find a paragraph obviously directed at prospective clients, which I must have written myself, and which I venture to quote:

> "During the nine years of its existence, there has been developed at the Experiment Station a Corps of specialist-engineers. These engineers constitute the unique and irreplaceable element in the Station's facilities. They represent the priceless product of nearly 250 model studies accomplished to date. Their talents form the invisible but highly important ingredient of every new study completed at the Station. Meanwhile, there also has been developed a small corps of expert craftsmen, skilled in such items as model making, pyralin-working, etc. Interesting in this connection are certain Mississippi negroes who, after nine years of training, have become unbelievably proficient at molding concrete in sand. All in all, it may be said with conservatism that the greatest asset of the Experiment Station is its specialist personnel."

The only change I've made in quoting that paragraph written 30 years ago is to underline the last sentence.

BG Paul W. Thompson (USA, Retired)
Executive Vice President
THE READER'S DIGEST
Pleasantville, N. Y. 10570

CPT Kenneth E. Fields
Sept 1939-Dec 1941

I am sorry that I am unable to recall details sufficiently precise to write anything of value for the WES History. I cannot find my records and my memory fails in definite details.

To the best of my recollections, however, the nearly final draft (of the History) sent to me 22 March reflects very well the significant events of historical interest occurring during the time I was at WES.

The aspects I recall most poignantly are of no historical interest, such as:

a) The first steps to do some expense budgeting were taken by Tiffany and me in the fall of 1939, immediately following my return from Omaha. There, the then COL Hogue, had roasted me to a burnt brown because a model study of bed flow in the Missouri had cost about 50-100% more than the $1200.00 estimate! (The figures are suspect, but the total cost was small and the increase large.)

b) Some emergency flood-control measures we had to take to preserve the main building.

c) The plethora of spillway and outlet works studies undertaken. I believe this support to the Districts in this early period and the good and timely work done helped materially in the understanding throughout the Corps of what a WES-like institution could do for the Corps.

BG Kenneth E. Fields (Retired)
561 Lake Avenue
Greenwich, Conn. 06830

LTC Clement P. Lindner
Oct 1945-Dec 1945

With respect to my tenure as Director, a number of important things were going on, no doubt, many of which I cannot recall. The ones I do remember are as follows:

a. We made the decision and initiated action to obtain the first hangar for a model shelter.

b. Study of surges in a Pacific Island Harbor (I believe it was Wake Island) was under way.

c. Report on a lock arranged for the flushing of salt water was completed. This probably was the Raritan River report.

d. I promoted the idea of sectionalizing the Mississippi River Flood Control Model (the Clinton model), so that various parts of the model could be used on separate studies or the entire model could be used at one time. To do this proved to be a valuable decision.

e. The provision of housing on the Station grounds, more or less as an emergency measure, was initiated.

f. Although this has no place in any history, when I became Director I found that action had been taken to obtain time clocks and job clocks for the Station. I canceled this action, as I considered the punching of time clocks obnoxious and unprofessional. I feel that that was a service to the Experiment Station.

g. Of course, you realize that pavement tests and test reports were under way, but I cannot be specific on these. So was Dr. Fisk's study of the Geology of the Lower Mississippi River for which we furnished illustrating service by assigning an Artist Illustrator full time to Dr. Fisk.

C. P. Lindner (Retired)
Engineer
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COL Carroll T. Newton
Jan 1946-Dec 1946

A. General.

With the termination of World War II in mid-1945, the Station was confronted with a heavy program of studies for long-delayed Civil Works Projects. The physical plant and technical capacity required drastic expansion. The Director of Civil Works, OCE, BG Stratton, and the President of the Mississippi River Commission, MG R. W. Crawford, were both very helpful and influential in producing the required resources to initiate and carry out major changes in organization and facilities.

The Experiment Station, since its inception an element of the Mississippi River

Commission, experienced some awkward situations in communicating with and serving Divisions and Districts on a Corps-wide basis during this period of expanding activity. However, the Director and key professional personnel remained directly responsible for the technical adequacy of all reports and studies. The MRC gave strong support to and maintained close concern with development and improvement of physical facilities.

Master planning, instigated by OCE and with assistance of key OCE staff representatives as a "Board," encompassed both the Vicksburg and Clinton Reservations. Long- and short-range plans, including philosophies of consolidation of Corps of Engineers Research and Development activities, contributed to the practical exigencies of early action under direction of the MRC.

From late 1945, throughout the spring of 1946, personnel were returning from military duty to exercise reemployment rights at the WES, the MRC, and Vicksburg District. Additional employment, to meet the increased work loads, compounded the problems of simultaneously instituting new studies and providing the necessary physical plant.

B. Physical Changes - Vicksburg.

1. The Reservation.

An immediate result of the "master planning" exercises was the acquisition by purchase of adjoining property. Usable acreage was increased by more than 50 percent. A widened and paved access road to serve the Station from the west and north was realized with assistance of the community officials. Internal road communications were pushed through with Station personnel and equipment to facilitate utilization of the expanded real estate. Extensive clearing and grading, knocking off mounds, and placing compacted fill in gullies were resorted to in order to provide broad level areas for model shelters and soils studies.

A heavy construction program was obviously necessary, but desired materials were impossible to obtain. Accordingly, war-surplus equipment and supply lists were closely scanned and requisitions placed in the hope of obtaining material that might be usable. Some orders were never filled; but for others, shipments were duplicated, resulting in heavy stocks of lumber and hardware, plumbing and electrical wares, some machine tools, earth moving machinery, and, most important of all, numerous portable hangars and portable buildings.

2. Hydraulics Division.

In late 1945, the facilities for hydraulic models were quite inadequate. Flumes for hydrodynamics were in the "main" building below the dam. Wooden sheds for river and harbor models gerrymandered on both sides of the creek on the "lower" level. The "upper" level comprised "Old 94," the

St. Lawrence River model shed just at the top of the rise, and a pump house to circulate water from a small artificial reservoir.

New model study projects demanded adequate space and facilities. On the graded "upper level," the portable hangars obtained from "surplus" proved to be the ideal solution at the time. Adjacent thereto, portable sheet steel warehousing from surplus was erected for some of the river and bay models. A new Hydrodynamics Laboratory was installed in a hangar, fitted with an adequate supply of circulating water, pumps, controls, and instrumentation.

The center of activity for hydraulic model studies, by the end of 1946, had been completely removed from the "lower level" to new facilities on high ground.

Gene Fortson, Brad Fenwick, Fred Brown, Henry Simmons, Bob Hudson, Lipscomb, and Franco were particularly responsible for significant progress in those hectic days.

3. Soils Division.

The Soils Division (designated by a longer and more cumbersome title in 1945) comprised the Soils Engineering and Laboratory Service for the Lower Mississippi River Division; the Flexible Pavements Laboratory for Military Construction in OCE; field crews for limited terrain studies for the Air Corps and trafficability analyses for the Army Ground Forces; and also soil sampling and drilling crews. Some of the Laboratory activities were conducted in space made available in the National Park Service Headquarters, a few miles distant from the reservation.

The Soils Laboratory was relocated into the central portion of the "main" building as the hydrodynamics apparatus was removed. Expanded field office accommodations and heavy equipment were provided in the vicinity of the paving test area.

Dr. J. Hvorslev joined the staff and published his comprehensive and remarkable treatise on Soils Sampling.

Bill Turnbull, assisted by Charlie Foster, Keith Boyd, Stan Johnson, Bill Jervis, Charlie Mansur, Bill Perret, Ray, and Tommy Goode, enhanced the already outstanding reputation of that fine unit.

4. Construction Services.

As the model sheds on the "lower level" were replaced by new and better facilities on the "upper level," an orderly shops and service area emerged, handily adjacent to the main service entrance on Halls Ferry Road.

A heavy equipment yard developed on the "upper level," adjacent to the pavement test pad, handy to the work area.

New utility lines, heavy power, and increased water supply were provided throughout the reservation, in general, following the new roadnet.

Design, layout, site preparation, construction, and installation of equipment for all the new and renovated facilities were performed by force account, necessitating, at times, a service labor force numbering in the hundreds.

George Vinzant, Heinie Warndof, and Gorman Schaffer ran this show.

5. Housing.

Provision of housing for key Corps of Engineers personnel in the Vicksburg area was a critical problem in the early postwar period. The single set of quarters on the Station, originally built for the Director, was expropriated in the fall of 1945 for the personal use of the President of the Mississippi River Commission. By his direction, and frequently with his personal supervision, a dozen single family dwellings were sited about the lake; architectural detailing was performed by the Staff Architect of the MRC, Mr. Raymond Birchett.

Station construction forces were expanded to handle erection of the homes; extreme difficulty was experienced in obtaining adequate and appropriate supplies of lumber, wall board, plumbing, and lighting fixtures. Thanks to war surplus and innovation, the homes were occupied within about five months from the start of the program, November 1945.

The second phase of the housing program consisted of the construction of about six units, containing an average of six apartments each on property newly acquired.

Another housing expedient was installed, a trailer camp of four units with special building for shower and laundry. This required excessive maintenance and, due possibly to the remote location, was not too popular.

Housing was assigned by the MRC to employees of the Division, District, and Station, according to a procedure based on position and need.

The housing community, for a while, even supported a neighborhood store operated by a concessionaire in a building provided by the Station.

To keep the little lake attractive for fishing and appearance, underbrush was cleared along the shore and a constant battle was waged to trap turtles; the Director received a weekly "turtle report," which, on one occasion, listed a three-foot alligator.

C. Physical Changes - Clinton.

1. General.

In the fall of 1945, at the Clinton Prisoner of War Camp, a cadre of WES personnel, under the direction of CPT H. G. Dewey, was providing technical direction to talented German prisoners in laying out and initiating construction of the Mississippi Basin Model. Transfer of the entire reservation from Military status to the WES as a Civil Works facility was accomplished by mid-1946; the confusing and frequently humorous details of clearing the prisoners and effecting this unprecedented transfer provided an interesting feature to a very challenging tour.

2. Mississippi Basin Model.

Construction of the big outdoor model was changed from the hand labor operation of the prisoners to a project involving the utilization of appropriate heavy machinery. Master utility lines, pump houses, and water supply piping were laid out and installation was initiated. Initial installation of control instrumentation was made and tested. H. G. Dewey remained in charge as a civilian employee. Adequate accommodations for engineers and technicians were provided by means of the hospital building of the prisoner camp.

3. Concrete Division.

As the first step in the abortive program to consolidate research and testing laboratories of the Corps of Engineers, the Concrete Laboratory was moved from Mt. Vernon, New York, to the Clinton Reservation to become the Concrete Division of the Waterways Experiment Station. A laboratory building, designed by Staff Architect Birchett of the MRC, was constructed on the Clinton site. Carl Wuerpel was the guiding supervisor of the Concrete Division establishment.

4. Housing and Services.

Living accommodations were as inadequate in the Clinton area as in Vicksburg. As a partial alleviation, several of the small tar-paper finished prisoner senior officer quarters were renovated to provide housing for key employees.

Construction and maintenance services at the Clinton reservation were provided as a subsidiary activity of Construction Services at Vicksburg. Al Davis was in charge.

D. Organization and Control.

1. General.

By late 1946, all activities at the Station were humming at a heretofore unprecedented rate. Supervision and control from the Director's office were exercised through three senior responsible officials: Joe Tiffany, Technical Director, for all technical studies and operations; George Vinzant, Director of Construction Services, for all new construction, maintenance, shops, crafts, security, and fixed or movable plant; and Bill Bache, Director of Administration, for cost accounting and finance, personnel, procurement, and office services. A military assistant, MAJ Tommy Hunter, was assigned special studies and as monitor of critical programs.

2. Cost Accounting and Fiscal Management.

The key to effective management at the Station was determined at an early date to lie in the financial control. Prior to 1946, finance and accounting service had been provided to the Station by the Vicksburg District. With greatly expanded activities, direct control of cost accounting and fiscal matters at the Station became mandatory. With the assistance of the MRC, an outstanding young man was recruited to establish and supervise administrative procedures. Bill Bache always exhibited the attitude of "Let's find a way to do it."

Plant accounts, transferred from the Vicksburg District, were refined and revised within the guidelines of the Civil Works Orders and Regulations (O&R) to more appropriately reflect laboratory activities. A zoning and numbering system for buildings and fixed facilities was instituted; current and realistic rental and depreciation rates were determined and applied.

Financial forecasting and budget programming were introduced by functional areas. A functional numbering system placed into effect to identify projects, reports, and applicable cost accounts has proven itself through years of utilization.

In 1946, the precedent was established that maintenance of the Station in being, the Library, and Research Center, were of benefit to the Corps of Engineers at large; accordingly, a modest subsidy for some overhead expenses was alloted from OCE. In this manner, indirect charges to client offices were held to a modest rate.

3. Technical and Supporting Services.

Excellence of report preparation became an objective--as the final product of research or model studies. Service elements, including the Library, Photo and Reproduction, Drafting, Reports Editing, and the Research Center were set up or revitalized to provide coordinated "Technical Service" to the Study Production Divisions.

An indispensable element to the Station was the Instrumentation Branch; Gene Woodman kept abreast of latest developments and created, in spite of consistently poor accommodations, a remarkable capability and capacity to respond with ingenious apparatus appropriate to the requirement.

The Library, which occupied Quarters No. 1 during some of the war years, was reestablished in the "main" building on the first floor below the Director's Office.

A feature that relieved operating elements of considerable diversion was the establishment of a "Visitor's Bureau." Camile Lefeve developed procedures and publicity that resulted in well-earned acclaim.

With the increased size and activities of the Station and the emergence of a tenant community, protection, security, and maintenance became important considerations. A fire squad with equipment and a guard force to check and patrol were organized. Maintenance of grounds and buildings was a new and constant requirement. Accordingly, a maintenance and security group evolved as the responsibility of George Meaders; Bob Mobley directed the efficient guards.

E. Summary.

Although the tour was relatively short for a Director, the opportunity to serve in the immediate post-World War II period was challenging. In that brief time interval, the energy, competence, and team effort of key staff members from the existing organization, returnees from military service, and new hires determined and initiated the pattern for subsequent physical growth and expanded operations. The master plan for development of Station facilities and basic procedures for cost accounting and fiscal management were evolved. The Station developed from a dependent subsidiary activity to a self-sufficient organization prepared for independent status, as an agency reporting directly to the Chief of Engineers.

COL C. T. Newton (USA, Retired)
Swindell-Dressler Company
441 Smithfield Street
Pittsburgh, Pa. 15222

COL John R. Hardin
Jan 1947-Mar 1947

When I arrived in Vicksburg in January 1946 and was made deputy to MG R. W. Crawford, I learned of the action he had taken to expand the area and facilities of the WES. It is possible that some of these plans had been initiated by GEN Tyler, but I remember how much personal effort GEN Crawford put into this work in persuading OCE of its necessity, obtaining surplus war materials from various military commands for building new laboratory facilities and desperately needed housing, and buying or condemning real estate for more space. I mention these points because the Station was directly under him.

It also occurs to me that the support for an expanded WES may have developed as a result of the Station's real contribution to World War II planning studies. A large public works program was also in the making.

I recall that we had some extensive revetment failures preceding or in the first part of my duty with GEN Crawford, and it was difficult to give good reasons for these failures. Costs of the work were rising so rapidly as to be a matter of great concern. The realization of a 12-ft navigation project for the Mississippi River, which had been recently authorized by Congress as a by-product of a new revetment program, appeared to be in jeopardy.

As his deputy, and with GEN Crawford's support, I began devoting much of my time to the revetment problem. I soon formed the impression that the engineering involved was more of an art than a science. Engineers dealing with planning revetment work had generalized concepts of the effect of revetments and the cause of their failure, but the degree of finite technical knowledge appropriate for designing revetment systems, rather than spot protection, and spending great sums of money on the task, seemed inadequate to me. Being familiar, by this time, with the meander model study by Friedkin and the Fisk Report on Mississippi basin geology, I formed the opinion that WES should be used in an effort to develop an improved technical base for stabilizing reaches of the river, for determining the causes and demonstrating the mechanics of revetment failure, the adequacy of the articulated concrete mat or improvements which should be made, etc.

At about this stage I recall holding a meeting at the WES and I outlined the problem somewhat as indicated above. I believe I saw my remarks in some of the Potamology papers loaned me in 1963. Whether or not at the time of the meeting I was acting as the deputy to GEN Crawford or as the Director of WES I cannot recall.

My tour as Director (in addition to my other duties) was very short indeed. It seems to me it lasted only a few months, and I can recall little of importance for a history. I remember encouraging, in one way or another, the construction of facilities, the development of movable-bed model techniques, and the testing of various materials for such models. I also remember pushing for the development of instrumentation for measuring the forces on revetments. I would imagine that the monthly progress reports for this period (if they survived the fire) would be a better source of information than my inadequate memory.

After leaving Vicksburg in April 1947, I lost contact with the Station. With the pressures of other assignments I was unaware of what problems the above-mentioned program encountered. It was a great disappointment to me to find on my return in 1953 as President, MRC, and Division Engineer that even the publication of the Potamology studies had been denied.

To sum up my period as Director I have to say that although I participated in the expansion program under GEN Crawford, as mentioned above, I remember no major changes which were effected in my time; and I regret to say I can claim no major accomplishments although at one time I was somewhat hopeful.

MG John R. Hardin (USA, Retired)
Consulting Engineer, Wittman, Md. 21676

LTC Ralph D. King
July 1947-July 1950

Actually, I suspect there is little that I can add which might be of value in the preparation of the WES history. Unfortunately, about three years ago our house burned down - and although there were no physical injuries - I lost quite a few of my records and mementos. I find I have practically no files or literature on the Station which could have helped what has always been a very poor memory - and twenty years is a heck of a long time - with no intervening contacts.

Commenting strictly on the basis of memory, I believe there were very significant accomplishments during the 1947-1950 period. Believe we were fortunate in getting the funds necessary to make many Station improvements including the new hydraulics buildings and hangars on the hill, clearing out the old buildings down below and creating a respectable entrance, paving the roads, and improving the water supply. At Jackson, the Concrete Research Building was activated and the big Mississippi Basin model began to produce results. As I remember it, we made great strides in the pavement and trafficability studies, even providing some assistance in the Berlin airlift. Other things that come to mind include the transfer of the Station to OCE, the creation of the position of Technical Director (I believe), the riotous parties at the Army-Navy Club, inspecting the station on horseback, etc.

Joe, I know your records and your personal knowledge can best determine what should be included in the history. I won't attempt to give any real advice in the matter. My remoteness in both time and distance is too great. I'm sure you and the others will turn out a great job.

COL Ralph D. King (USA, Retired)
Vice President
Lockheed Missiles & Space Company
Menlo Park, Calif.

COL Herrol J. Skidmore
Aug 1950-Aug 1952

I have started, many times, to compose a suitable summary of the highlights of my tour at WES, the problems, their solutions, and the milestones during my all-too-brief assignment (August 1950-August 1952). I find that my files are inadequate, factually, to permit more than generalities which are, no doubt, colored more by my cherished recollections than they are supported by facts, either timewise or in relative importance. With this explanation, and apology, where fantasy and fact are at variance, I shall try to cover briefly my remembered highlights.

The one most-serious problem facing WES at the time of my assignment was the removal of WES from the aegis of LMVD and the consequent need for WES to look elsewhere for much of the support LMVD had been providing as a matter of routine. WES had to find new areas to develop and new activities to undertake or face a serious reduction in staff and curtailment in operational overhead. Virtually my entire tour was devoted to the search for new and expanded areas of activity. Our preparation of our first "Statement of Capabilities" and its presentation to and acceptance by AEC was an initial major success in our program. Simultaneously, we explored the extent to which our support facilities could provide support for others. Specifically, our reproduction facilities expanded their work for AMS and undertook publication of training material for the Air Force; our Soils Division engineers and field teams undertook a wide range of projects for others, most notably their field work and design support for the Charleston District on the Savannah River AEC facility; our Research Center capability was expanded to permit translation service for technical intelligence activities; and the entire range of our military research effort was expanded, especially in the aerial-interpretation aspects of trafficability. A most interesting study undertaken in the Hydraulics Division was that of design of control structures for Niagara Falls. The study, undertaken jointly with Canadian representatives of Ontario Power, achieved most spectacular (literally) success! Of the special studies undertaken for OCE, I recall especially initiation of the Prototype Analysis Program that has developed so successfully. Needless to say, we never had to curtail our operations; in fact, our horizons and the scope of our activities expanded continuously.

My arrival at WES coincided with the departure of the Organized Reserve Battalion, made up in large part of key WES personnel, for Korea. My anxiety at their departure proved groundless. I soon found that WES was organized in such depth and of such caliber personnel that every new problem could be adequately staffed, promptly attacked, and properly solved. Nowhere have I seen the motto of the Corps of Engineers, "Essayons," exemplified to better purpose than at WES in 1950-1952. We not only landed on our feet, we landed running! For the fine showing made at that time, and since, I can take no credit. The technical and administrative staffs met every assignment willingly and capably. I cannot single out individuals to compliment; it was a team effort that produced the results. I consider myself most fortunate to have been assigned to WES during that trying, and rewarding, period.

COL Herrol J. Skidmore (USA, Retired)
Professor, Department of Civil Engineering
Marshall University
Huntington, W. Va.

COL Carroll H. Dunn
Sept 1952-May 1955

My personal records covering my period of service at WES are in storage and unavailable to me; however, I am commenting in the following paragraphs on those items that stand out in my memory as having more than routine interest or significance for the Station.

Personnel Reduction, 1952. As a result of DOD imposed freeze and required review of all on-going programs, WES faced an immediate strength reduction of approximately 25 percent. This occurred at a time when opportunities for placement of released people in other areas, either public or private, were not particularly abundant. Nevertheless, through a program of extensive personnel and public relations, this traumatic experience was weathered with minimum disruption to the long-range capabilities of the Station as well as with minimum impact on the individual personnel affected. As I remember it, all personnel released who desired continued employment were assisted in finding employment. This drastic reduction calls into question a specific area of WES operation which requires continuing review. I refer to the fact that the Station has very limited sustaining funds and is primarily dependent upon reimbursement from those for whom research and development activities and investigations are undertaken. When there is a major disruption of normal funding, this has a particularly heavy impact because of the tendency for cancellation of long-range studies. In spite of these difficulties, I am convinced that the industrial-type funding is most desirable and is an outstanding management tool to control expenditures, monitor work in progress, and give assurance to customers that their projects receive top level attention. In spite of this, however, further study is required to minimize effects of major abrupt program changes.

Vicksburg Tornado, 1953. This project is covered elsewhere in the history. My brief reference to it will be simply to point out that the organization in-being at WES responded magnificently to this natural disaster. Through the in-house capability of WES, emergency evacuation of the injured and recovery of the dead was expedited.

Nuclear Weapons Effects Capability. This program had started on a limited basis in the early 1950's. As the area around the main installation of WES became the location of additional housing development, this program, which involved setting off small explosive charges, became a major public relations problem. With increasing demands placed on the Station for further work in this field as a result of their successful completion of earlier assigned projects, it became very clear that, if such work was continued, a new location was required. The decision was made, therefore, to develop this capability at an isolated site on the Big Black River. This site was developed and greatly expanded the capability of the Station in this unique field. As a result of this expansion, continued work was assigned and increasing recognition came to the Station for their capabilities to carry on explosives research and related instrumentation projects as well.

Mississippi River Basin Model. This subject is also covered elsewhere in the history but at a major turning point during the 1952-1955 period, after thorough review of the project, the decision to continue it to completion was made. The method of financing was changed, resulting in direct congressional appropriations. The instrumentation program was also reviewed, with major reduction in number of instruments required.

Enlisted Personnel Program. This program, also covered elsewhere in the history, was initiated to take advantage of engineering and scientifically trained manpower available as a result of the draft. Not only did it offer an opportunity for these personnel to serve in a challenging professional position after completion of their basic military training, but it also provided a major source of recruitment for continued employment under Civil Service appointment after completion of required military service. In my opinion this has been a very successful program for the individuals concerned and for the Station.

Continued Operation of WES as a Separate Organization Directly Under OCE. As indicated elsewhere, WES originally was a subordinate organization of the Mississippi River Commission. Recognizing that its field of endeavor greatly exceeded the area of interest of the Mississippi River Commission, the Chief of Engineers, in 1949, transferred the Station from the supervision of the President, Mississippi River Commission, to the supervision of the Assistant Chief of Engineers for Civil Works in OCE. During the 1952 to 1955 time period, as a result of recommendations from various individuals, including two presidents of the MRC, further study was given to reversing the supervisory assignment of the Station. As Director of the Station at that time I strongly opposed these recommendations, and based on continued observation of its activities in the succeeding years, I have not changed my position. There is absolutely no justification for the Station to operate under MRC and there are numerous disadvantages to any such assignment. It is my hope that this question has now been permanently laid to rest. Throughout its nearly forty years of existence, and particularly its last nineteen, the Station has proven its capability to operate effectively as an independent, well-qualified research, development, and investigative organization. Neither its current eminence in many fields of engineering nor its attraction to highly qualified individuals would have resulted had not its change of assignment and increased breadth of interest and competence been made in 1949.

Twenty-five Year Celebration. Certainly a high point of my tour as Director was the celebration of the Silver Anniversary of the Station, 18-20 June 1954. This celebration gave an opportunity to review all of the programs in which the Station had been involved since its beginning. The return of most of the former Directors provided an opportunity for renewal of friendships and served in large measure to create a renewed sense of purpose in all personnel of a most unique organization. The publicity as a result of this event brought forcefully to the minds of the people of Vicksburg the importance of the Station to their community. At the same time, national publicity helped to focus attention on the accomplishments and capabilities of this organization. As it approaches its fortieth year in operation, the accomplishments of the Waterways Experiment Station are recognized throughout the world. It continues to add new pages to a history replete with scientific and engineering achievements. All who have had a part over the years in its activities can take pride in these accomplishments.

My three years as Director of WES I consider a significant highlight in my Army career. The personal and professional relationships resulting from that tour have been extremely valuable to me.

MG Carroll H. Dunn
Director of Military Construction
Office, Chief of Engineers, Department of Army
Washington, D. C.

COL Andrew P. Rollins, Jr.
June 1955-July 1958

During my tour as Director from 1955 to 1958, I consider that I had five principal problems. I consider the major technical problem to have been the development and proof of heavy-duty asphaltic concrete pavement for airfields. As you will remember, the repetitive use of Air Force heavy bombers with bicycle landing gear was causing pavement distress due to canalized traffic. You will also remember our work on pavement design and the building and testing of test sections at the Station itself, Kelly AFB, and the Columbus, Mississippi, AFB.

The second problem that worried me was trying to keep an adequate level of funding for our concrete research program and the basic type of research effort we felt necessary in hydraulics and soils mechanics. I think my third problem was securing adequate capital funding for major construction at the Station necessary for expansion, i.e., model shelters.

The fourth problem was one that required constant attention and I am sure worried the other Directors. This was the effort required by all of us to reduce and hold to a minimum the Station overhead charges. Lastly, but not least, was the ever-present problem of attracting and recruiting young engineer talent.

Following your outline, I thought about major changes effected during my tour but did not consider any that would so qualify.

Regarding major accomplishments, I can think of three in this category. The first was our proving out the capability of heavy-duty asphaltic concrete pavements for airfields. The second was our getting under way the in-house research program of the Mobility Research Center. Third and last was the procurement, installation, and use of an in-house computer capability at the Station.

Additionally, I would hope the history would cover the participation of the Station in the National ASCE Convention at Jackson in the Spring of 1957. This was certainly the biggest public relations effort that the Station was involved in during my tour.

BG Andrew P. Rollins, Jr.
Director of Construction
Headquarters, U. S. Military
Assistance Command, Vietnam (MACDC)

Editor's Note: As stated above, the American Society of Civil Engineers held a national convention in Jackson, Mississippi, in the spring of 1957, during Colonel Rollins' tour as Director. A very considerable number of the members of the committees planning for and carrying out the convention were made up of WES employees. Conspicuous in the ASCE Program were tours of the Waterways Experiment Station installations at Vicksburg and Jackson.

COL Edmund H. Lang
Aug 1958-Aug 1961

If these notes be intended as raw source data for some small portion of Waterways Experiment Station history, the reader deserves a check upon his perspective. These notes will do little to tell about the delightful people of the Station and of Vicksburg or of their warmth and joy. They do aim to tell about the events of three active years as I saw them from the office of the Director and have been written with less restraint than I would have accorded them if on active duty. I hope they will be recognized as the product of a memory beyond the young colonel syndrome and can be treated so as to hurt the feelings of no one.

Assignment

My assignment to Vicksburg was unexpected. The first inkling came by way of radio-telephone to the U. S. Lake Survey hydrographic survey boat in the middle of Lake Superior. Was there anything the Chief should consider if I were to be ordered to another assignment? There were several.

As District Engineer, U. S. Lake Survey, for but one year, I had time only to become acquainted with the organization and with the range of things in need of doing. The U. S. Lake Survey was active in Great Lakes hydraulic and meteorologic studies. It participated in St. Lawrence Seaway and Niagara Power studies. The professional staff was starting to upgrade its professional stature. The embryonic research program showed promise and also showed prospects of getting support from the Chief, such as I believe it should have had over three or so decades previously. Our children were in the best of public schools and deserved to stay in one for a while. Our son had been in a different school each year. We thought the regime had changed and were concerned about the consequences if it continued.

As should be expected under the circumstances, a call was recieved from the Office, Chief of Engineers (OCE), several weeks later with news that I had been selected as Director, Waterways Experiment Station.

Specific items

1. Destruction of the WES Administration Building by fire on October 3, 1960. This fire was the biggest event of my tour as Director. It changed the focus of activity by requiring extraordinary effort to overcome its effects and to plan a future with prospects better than ever.

Several items stand out more vividly than others: the brightness of the red sky when Bill Bache finally awakened Mrs. Lang and me by pounding on the bedroom window in Quarters No. 4--the hopelessness, as fire comsumed the roof and the whole of the new, "permanent" building--the hard work by a willing staff to save the original "temporary" building with solid walls.

When GEN Cassidy, Assistant Chief for Civil Works, OCE, was called and told of the disaster, his first question was whether any lives had been lost and whether anyone had been hurt. Since none had, this was the only immediate piece of good news aside from the actions of all to keep operating. In a later conversation, GEN Cassidy observed that funds for fire protection features which were unobtainable before WES burned would be forced upon installations afterward.

Normal activities continued with a minimum of interruption, from the Park Service headquarters, Vicksburg District space, and temporary rented and converted shed structures. IBM airlifted a replacement computer, and other equipment came through promptly. Operations at this time sacrificed efficiency for expedience, but they permitted the Station to meet its commitments with some semblance of respect for earlier agreements. Findings of the board appointed to ascertain cause of the fire identified a failure of fluorescent lighting fixtures against a flammable acoustic tile ceiling as the likely cause. The report brought out the high risk of fire involved in the building. Earlier daytime fires caused by defective ballasts and transformers in lighting fixtures gave some indication of the hazard involved, but I had no idea of the hazard from asphalt-impregnated kraft paper used as a vapor barrier over fiber glass insulation. When this caught fire, as a welder cut through sheet metal on a back wall of the building, disaster was delayed but a short time. Such ballasts and insulation are supposed to have been improved, but the worst fire in the Post Office in 180 years (Morgan Station, NYC, December 15, 1967) got out of hand when asphalt-impregnated vapor barriers on adjoining air-handling ducts began to burn.

The most important action for the future was to appoint a small committee of senior WES officials to plan for the future and to recommend an architect to carry out their plans. I was due to leave in a year, continuity was essential, and whatever was built had to be sound functionally. Since a poor architect costs as much or more than a good one, an effort was made to obtain one who could design a building to be both beautiful and functional. The committee was impressed by certain Millsaps College structures and recommended the architect responsible.

Although I would like to have gotten construction under way, and little time was wasted in planning or design, every effort was made to avoid blunders which ought to have been foreseen. The Vicksburg District was consulted about construction but had had little or no work of this type for many years. The Mobile District had had a falling work load and undertook to review the architect's work, revise the specifications to fit into Corps of Engineers format, and to put contracting documents in order as they applied to plans and specifications. Others must judge the success, but I was surprised to learn later about one District Engineer citing this case as the reason for the Chief, GEN Wilson, withdrawing the long-standing WES authority to do its own construction!

The size of the new building had extensive and detailed screening in OCE. The Chief himself insisted upon close control over the square feet per man in terms of the work force at the time. A few years later, planning may have appeared inadequate, but I believe Bruce Tucker, Lower Mississippi Valley Association, can confirm the good fortune of WES in getting as much as it did.

With respect to the destroyed building, a first reaction to clear the ruins and move from a flood-threat area soon recognized the urgent need for more satisfactory office space. Installed utilities, sound slabs, and portions of a good wall made it most economical to rebuild and recognize the incipient flood threat through controlled occupancy.

Reestablishment of the library proved to be most satisfying. WES had the best hydraulic library in the United States. Its annotated card catalogue was lost and could not be replaced. Regrettably, a proposal to avoid this loss and protect 30 years of professional effort had been made and was turned down. This came to light when GEN Vogel, Chairman of Tennessee Valley Authority, sent representatives to help WES in whatever way they could. Their discussion brought out that a Bureau of Reclamation representative had written to obtain a microfilm record of the card catalogue with its evaluation of the technical works listed. This microfilm was to be made available to university libraries. Approval of the small expenditure involved was denied unless the recovery of the full amount were assured through prior commitments to purchase the microfilm copies at a cost to make this possible!

Replies to inquiries and releases about the fire requested the donation of reports, books, and other lost items needed to reestablish the collection. The response was nothing short of being amazing. Important personal collections were forwarded so as to place them where they could do the greatest good.

This effort had an unexpected sequel when the OCE Executive Officer flabbergasted me with information from the Chief that WES must be proud of its fire!

2. Early publication of reports. The first set of instructions to me about a place where change was needed applied to reports. WES gave the results of its work promptly to those who paid for studies, but the rest of the Corps was unable to use the findings because reports were not completed and distributed for years. Engineers preferred to work on new investigations, generally considered reports a drudgery, and could not let demands for results applicable to projects under design interfere with reporting past results. The status of any individual report being prepared remained obscure until sent to the printer. Basically, the reporting system used the same terms several times to identify the point in processing. After two years with concerted effort by all, the backlog was being reduced substantially when the fire caused a further delay. Mr. Tiffany managed to get this reporting effort moving. I believe the key was a forced system of estimating key times in the process and surveillance to learn reasons why milestones were not being met.

COL Edmund H. Lang (USA, Retired)
2840 Fort Scott Drive
Arlington, Va. 22202

COL Alex G. Sutton, Jr.
Aug 1961-Dec 1964

To summarize what I consider major accomplishments during my tour as Director, I would list the completion of the blast load generator, the new administrative building, some of the larger hydraulic models, and other major construction projects; the reorganization of the WES to include the formation of the Office of Technical Programs and Plans, the Nuclear Weapons Effects Division, and the Mobility and Environmental Division; the preliminary work and agreements which ultimately led to the establishment of the graduate training center; our participation in and contributions to various joint committees and working groups; the preparation of the long-range master plan for the WES which led to the move of the Concrete Division from Clinton to Vicksburg; and the purchase of additional land for future needs, etc.

COL Alex G. Sutton, Jr.
Field Director
Atlantic-Pacific Interoceanic Canal Study Commisssion
Balboa Heights, Canal Zone

COL John R. Oswalt, Jr.
Dec 1964-June 1968

I have reviewed most of the history and much of what I might say has been covered in detail in the history of the different divisions, branches, and separate offices. My comments will therefore be general with mention of some of the things which I have tried to accomplish or which have for one reason or another been under close surveillance of the Executive Office. None of these are novel. Previous Directors have recognized and worked on the problems and I am sure that those who follow will continue to work on most of them.

One thing that I have tried to do is to delegate a greater authority to the Division and Branch Chiefs. They need the flexibility to operate and the Station needs to take advantage of their wisdom and accumulated knowledge. While the paper work continues to grow, I do think that this delegation is of considerable assistance in reducing the load on all of us.

I have stressed the need for analytical work concurrent with our experimental efforts. We have a unique opportunity here to make a successful marriage between good engineering based on wide practical experience and a developing theory that will produce better engineering in the future. Neither pure theory nor pure experiment is an answer by itself. The two must proceed together. The Waterways Experiment Station has unequaled capabilities for experimental work, both in the laboratory and in the field, but we do need to stress analysis more. In most areas of interest, considerable improvements have been made and will continue.

In order to improve analytic capabilities, we have needed badly a means by which our personnel can continue their education through advanced postgraduate work. The need has been partly fulfilled by the establishment of the Graduate Center in conjunction with Mississippi State University. Continuing education has been a long-standing problem at the Station and work toward a Graduate Center was started by Ed Lang. It is a real pleasure, therefore, to be the one who finally got the Center going and the very wide participation which it enjoys will greatly influence the overall quality of the Waterways Experiment Station staff in years to come. It was recently cited by the Deputy Assistant Secretary of the Army (R&D) as an outstanding example of what the Army has done to provide advanced study opportunities for laboratory personnel.

I have expanded the program begun by Alex Sutton of sending personnel away for one-year postgraduate instruction at various universities and have also expanded our program of bringing pertinent lecturers to the Waterways Experiment Station for short courses in topics of interest. In conjunction with the Graduate Center, this program makes it possible for selected individuals to advance from a bachelor's to a doctor's degree while at the Station. In order to improve our capabilities for analysis, we must be able to promote personnel of outstanding professional ability without regard to their position on the organization chart. A pretty good start has been made on this one.

The recent past has brought dynamic growth to the annual work load of WES. The current FY 1968 work load is the largest in the Station's history and reflects the result of the continued increase in military functions work programmed to WES by OCE, AMC, Air Force, DOD agencies, and others. About 60 percent of the work is military, including a great number of projects which are directly related to the Vietnam War effort. We at the Station have every reason to be proud of the substantial contribution that we have made to the war effort and of the reputation that we have achieved of being an organization that responds rapidly to needs. WES contributions have been felt in such diverse fields as expedient airfield surfacing materials (landing mats and membranes), dust control, soil stabilization, protective shelters and fighting bunkers, artificial harbor design, geologic methods of finding aggregates for construction, and the detection and destruction of tunnels.

The landing mat program, in particular, has been unusual in that the Station was made the procuring agency in order to expedite production. Negotiation and execution of these very large sole source contracts posed unique problems for the Waterways Experiment Station.

Data processing deserves a special mention as we move toward a system of recording experimental data in a format suitable for complete machine processing. The system, being installed gradually, includes an increase of tape recorders, an analog to digital conversion unit, and enlarged computer facilities. A GE-420 computer will be installed about 1 June 1968 to replace the GE-225, which will be released about September 1968. The new computer will be about ten times faster than the GE-225 and will have four times as much main memory. It is anticipated that it will provide for the bulk of WES computing needs for the next three-year period. The remaining requirement in the form of extra large scientific problems will be provided for by use of data-transmission service.

To control the diverse WES program, a management information system has been developed. Pertinent cost information is being provided on an almost daily basis, enabling project engineers to plan and operate their projects on a current basis. While first efforts have pertained primarily to cost accounting, the long-range plan is to provide additional data involving personnel, procedures, formats, data elements, project definitions, and scheduling.

The Office of Technical Programs and Plans has become a most significant element of the Station's organization. It has completed a comprehensive long-range research requirements plan and is giving the Station a much-needed planning and programming capability.

Approximately 184 acres of additional land has been purchased to provide for future expansion of the Station. The new Shops building was completed and occupied in July 1967, providing badly needed space and improved working conditions for Shops personnel. The new Concrete Division building is scheduled for completion in early 1969. The Reproduction and Reports Branch building was completed and occupied in July 1966. The lake was dredged in 1966.

A number of key staff members have retired during the last three years. These have included Mr. G. W. Vinzant, Chief of the Construction Services Division; Mr. T. B. Kennedy, Chief of the Concrete Division; Mr. W. L. Bache, Jr., Executive Assistant; Mr. G. B. Fenwick, Assistant Chief, Hydraulics Division; Mr. F. B. Campbell, Chief, Hydraulic Analysis Branch, Hydraulics Division; Mr. T. B. Goode, Chief, Inspection and Exploration Section, Embankment and Foundation Branch, Soils Division; Mr. J. A. Harris, Chief, Office of Administrative Services; and Mr. J. M. McCaskill, Chief, Reproduction and Reports Branch. Much of the past success of the Station has been due to their energy, devotion, and competence.

COL John R. Oswalt, Jr.
Director
U. S. Army Engineer Topographic Laboratories
(Effective 15 June 1968)

Appendix V
HYDRAULICS DIVISION

1. Rouse and Ince in their History of Hydraulics refer to the vast hydraulic laboratory of the Corps of Engineers at Vicksburg. The vastness has come about through the assiduous application of hydraulic laboratory technology to specific problems arising in the river, harbor, and flood-control work of the Corps of Engineers over a span of almost 40 years. This does not infer an indifference to research, for even in the beginning there was a "Research and Publication Section," the Chief of which--J. B. Tiffany--conducted the research that in 1935 produced Paper 17: Studies of River Bed Materials and Their Movement, which today remains a classic reference of researchers in sedimentation. Much research has been entailed in developing modeling techniques for coming to grips with problems of ever-increasing difficulty, as those involving the transient phenomenon of tides, the differences in fluid densities, the elusive nature of dynamic forces, and the intricacies of long-period waves, hurricane surges, and tsunamis. Since the acquisition of Dr. G. H. Keulegan as resident consultant in 1963, a competency in basic research in fluid mechanics has been under development.

Organizational Development

2. The Hydraulics Division had its beginning as a river hydraulic laboratory, known as the Waterways Experiment Station, established in 1929 at Vicksburg, Mississippi, for the purpose of solving river regulation problems by means of experimental studies on small-scale hydraulic models, although the title "Hydraulics Division" was not formally to be adopted until 1939.

3. The founding of this hydraulic laboratory at Vicksburg in 1929 marked the first significant arrival on the American engineering scene of the small-scale hydraulic model, an engineering tool that had been in use in Europe since the turn of the century. The Corps of Engineers, in preparation for this undertaking, gained all possible information from European laboratory experience by sending some of its officers there for extensive study. While consideration was given to the layouts and facilities of the European laboratories when the Vicksburg laboratory was being designed, the conclusion was reached that the problems to be studied in the two cases were fundamentally different. In consideration of the larger discharges, wider floodplains, and greater lengths of the major American rivers to be studied in models, it was decided (with remarkable foresight) that the Vicksburg installation would require not only considerable indoor laboratory area but also a large water-supply system as well as extensive land areas to accommodate large outdoor models and to provide room for future growth. Also, a traveling fellowship to study European laboratory techniques provided valuable model experience for 1LT H. D. Vogel who

was to guide the beginning steps of the WES laboratory as its first Director.

4. By the end of 1930, the new laboratory was ready to begin operations on a 147-acre site located about 4-1/2 miles southeast of downtown Vicksburg. A brick and steel building provided ample office space, and also contained an experimental-laboratory hall around 8500 sq ft in area equipped with hydraulic facilities, such as sumps, pumps, and flumes, as well as open areas for indoor models. An 80-acre reservoir had been impounded to provide gravity flow to the laboratory building as well as to outdoor model areas.

5. The first model study at the WES was made early in 1931 (construction of the model was actually begun 20 December 1930) to check the extent of Mississippi River backwater in the Illinois River. Since this was such a rush job that time was not available to permit construction of a conventional model, the study was made in a model river channel carved in the earth with adequate precision for the necessary one successful test. Early in 1931 several more river model studies were undertaken. Because of the necessity for obtaining immediate results, and of the need to develop a degree of know-how in this new field, some of the earlier models were hastily and somewhat crudely constructed and tested. As personnel became better trained and more experienced in the following months, more elaborate results were obtained; and by the end of the first year, a small but efficient working organization had been developed to handle the projects that were being submitted to the laboratory in rapid-fire order.

6. By the middle of 1933, after two and one-half years of its operation, the hydraulic laboratory had undertaken more than 65 separate problems on as many models, and 14 of these were still intermittently active. The models in existence about the grounds and within the building of the WES at that time exceeded in both number and size those of any similar institution in the world. The waiting list of new model projects was at all times small, owing to the rapid turnover and the high degree of efficiency developed by the now well-trained and organized personnel.

7. LT Vogel devoted much attention to the selection and assignment of personnel, and to training them in available theory and techniques pertaining to the comparatively new science-art of hydraulic modeling. Early in 1934 he wrote of his laboratory personnel:

> From the first it had been deemed wise to build up groups, as needed, from young men of sound basic training, whose asset in every case was open-minded honesty. With character as a background, these men were trained in the best theory and given full opportunity to exercise initiative and ingenuity. The success of this plan has been evidenced many times. Starting with the best European practice as a basis, such improvements have been made in methods of construction and operation of models as to make the previous Continental efforts appear less important by comparison.

8. The first two years (1931-32) of experimental laboratory work were marked

also by the experimental evolution of the WES organization toward functional subdivisions. During construction of the laboratory facilities from November 1929 through December 1930, all work except planning and hydraulic design was performed by the Vicksburg District, and there was no laboratory organization. The first laboratory organization, developed with the beginning of experimental work in January 1931, consisted of three laboratory groups with a "group coordinator" in charge; the Hydraulic Group concerned with fixed-bed models and the Sediment Group with movable-bed models constituted the first-stage embryo of the present-day Hydraulics Division, while the Soils Group was similarly the earliest forerunner of the Soils Division. By October 1932, the volume and diversity of work had expanded beyond the capacity of a single "group coordinator," and two independent hydraulic sections (handling fixed-bed and movable-bed models) were established; but this two-group system lasted only until January 1933. These first two organizations were characterized by a lack of functional subdivision. While each group was assigned problems of a specific class, the group leader was responsible for and actually performed all work of design, construction, and operation of each of his models, at the same time carrying on all correspondence, doing his own drafting, and writing his report.

9. The functional subdivision of the WES had its real beginning in January 1933, as the organization was set up to consist of three "sections." A separate Construction Section was established as a service unit to free the technical units from the burden of construction details. At the same time an Administration and Reports Section was formed to provide clerical and drafting services, although the technical units continued to perform most of such functions. Also, the technical units were reorganized as a Research and Experimentation Section consisting of Group No. 1 handling fixed-bed models; Group No. 2, movable-bed models; newly formed Group No. 3, tidal models; and Group No. 4, soils laboratory work.

10. Functional subdivision under the directorship of LT Vogel reached its peak in September 1933 when the WES organization was changed to consist of the following three sections: the Experiment Section, Research and Publications Section, and Operations Section. The Operations Section took over all service functions, including construction, administration, and the soils laboratory. The Experiment Section, with Isham H. Patty as Section Chief, was relieved of all duties except design and operation of its models, and consisted of the following "groups": Group No. 1, first under James G. Jobes and later under James B. Leslie, concerned with fixed-bed models; Group No. 2, under Robert B. Cochrane, concerned with movable-bed models; and Group No. 3, under Henry Sargeant, concerned with tidal models. The newly created Research and Publications Section, with Joseph B. Tiffany transferred from the earlier Group No. 1 to become Section Chief, conducted technical experimental research pertaining to the WES work program and edited all reports that were to be published.

11. The preceding parts of this appendix have carried the early evolution of the overall WES organization far enough to establish clearly the developing identity

of the present-day Hydraulics Division. The parts that follow will be concerned only with the history of the Hydraulics Division, insofar as it is practicable to so confine them.

12. On 4 November 1935, the second Director, 1LT Francis H. Falkner, abolished the hydraulic Experiment Section with its "group" system and established in its stead a "project engineer" system. A group of the more experienced and able employees were designated as Project Engineers, and each was assigned a single model project for which he was responsible to no one but the Director or Assistant Director. Other personnel were placed in a pool of "assistants" from which Project Engineers requisitioned daily according to the needs of their projects. Serving in a staff capacity as advisors to both the Director and the Project Engineers were two Technical Assistants, Joseph B. Tiffany who was transferred from the abolished Research and Publications Section, and Eugene P. Fortson who was transferred from the abolished Group No. 1. This organization is shown on the Appendix III organization chart dated 1 March 1937.

13. CPT Paul W. Thompson, Director during the period July 1937-September 1939, abandoned the "project engineer" system. The record shows that he set up on paper an organization chart including a unit entitled "Hydraulic Division"; however, he never implemented or staffed such an organization. He established a "Hydraulics Laboratory" with J. B. Tiffany as Chief, and this was subdivided into Experiment Section No. 1 headed by J. M. Caldwell, Experiment Section No. 2 headed by E. P. Fortson, and Experiment Section No. 3 headed by V. G. Kaufman. No. 1 was concerned with tidal models, and No. 2 with hydraulic structures models, while both handled some river models; No. 3 was concerned only with the large Mississippi River Flood Control model, which reproduced this river from Helena, Arkansas, to Donaldsonville, Louisiana.

14. The Hydraulics Division was first established under that, its present title, about October 1939 by CPT K. E. Fields, Director during the period September 1939-December 1941. J. B. Tiffany was first Chief of the Division, which remained subdivided into the same three sections and with the same section chiefs as shown in the preceding paragraph. In the fall of 1940, the forerumblings of World War II began to affect the organizational elements of the WES, and several changes were made in the Hydraulics Division. In October 1940, J. B. Tiffany, Chief of the Division, was transferred upward to become Executive Officer, replacing 1LT Wright Hiatt who was transferred from WES. At the same time, E. P. Fortson, the next ranking engineer of the Division and Chief of Experiment Section No. 2, was called into active duty in the armed services. The Hydraulics Division was then reorganized as follows (see Appendix III organization chart dated 1 January 1941): J. M. Caldwell became Chief of the Division, while Chiefs of Experiment Sections No. 1 through No. 5 were G. B. Fenwick, F. R. Brown, V. G. Kaufman, E. H. Woodman, and C. B. Patterson, respectively.

15. It should be noted at this time that many of the personnel and organizational changes that took place throughout the WES under the exigencies of World

War II conditions are today somewhat obscure for the 1941-1946 period, owing to the rush nature of most of the work done as well as to the loss of records with the passage of time. Therefore, this Hydraulics Division history must no doubt omit many events of interest for that period.

16. The organization described in the second paragraph above did not remain intact very long. Section Chiefs Kaufman and Patterson were lost to the armed services in 1941. Fenwick became Assistant Chief of the Hydraulics Division in November 1941 and remained in that position until 20 January 1943 when Caldwell (Captain, CE, since August 1942) was transferred to OCE in Washington. (What happened to the organization of the Sections between January 1941 and 20 January 1943 is now mostly obscure.) In January 1943 the Hydraulics Division was split into two independent divisions, the Waterways Division and the Hydrodynamics Division, both subdivided into sections with functional titles (see Appendix III organization chart dated 14 April 1943). Fenwick (Captain, CE, since August 1942) was Chief of the Waterways Division, which was subdivided into a Flood Control and Navigation Section under E. B. Lipscomb, a Potamology Section under CPT H. G. Dewey, a Hydrology Section under R. G. Cox, and a Tidal Section under H. B. Simmons. Brown was Chief of the Hydrodynamics Division, which was subdivided into a Wave Action Section under R. Y. Hudson, an Electrical and Mechanical Section under E. H. Woodman, and a Hydraulic Structures Section under Brown in a dual capacity.

17. The above two-division organization of hydraulic functions of the WES remained in effect until early in 1944, when the three-division organization shown on the Appendix III chart dated 1 July 1944 was formed. CPT Dewey was made Chief of the newly formed Reservoir Operation Division, marking the beginning of the Mississippi Basin Model. CPT J. F. Friedkin replaced Dewey as Chief of the Potamology Section, Lipscomb assumed the additional position of Chief of the Hydrology Section, as Cox was lost to the armed forces, and Hudson took on the added position of Chief of the Hydraulic Structures Section.

18. CPT Tiffany, Executive Assistant to the Director, was transferred from the WES on 23 June 1945. Thereupon, the Waterways Division and Hydrodynamics Division were combined to reconstitute the Hydraulics Division, with CPT Fenwick as Chief of the Division. Records are not now available to indicate the sectional subdivisions within the Hydraulics Division at that time.

19. On 7 December 1945, E. P. Fortson, Jr., who had been ranking engineer of the Hydraulics Division upon his departure for military service in 1940, was returned to duty at the WES as Chief, Hydraulics Division, with G. B. Fenwick as Assistant Chief. The Division was functionally subdivided in the spring of 1946 as follows: the Structures Branch under F. R. Brown concerned with hydraulic structures; the Harbors Branch under H. B. Simmons concerned with tidal and wave action studies; the Waterways Branch under E. B. Lipscomb concerned with fixed-bed and movable-bed models; and the Mississippi Basin Model Design Branch under J. J. Franco, who had just

returned from military duty. This organization is shown on the Appendix III chart dated 1 July 1946.

20. In November 1946, the Division was subdivided as follows (see chart dated 1 January 1947): the Rivers and Harbors Branch under Fenwick concerned with river and estuarine problems; the Hydrodynamics Branch under Brown dealing with hydraulic structure and wave action problems; the Mississippi Basin Model Branch under Dewey (Franco having taken over a section in the Rivers and Harbors Branch); and the Instrumentation Branch under Woodman. The latter Branch was transferred out of the Division early in 1947. The Division and Branch organization then remained unchanged (as on chart dated 1 July 1950) through July 1950.

21. The Korean War had a drastic effect on the Hydraulics Division as the 434th Engineer Construction Battalion, a U. S. Army Reserve unit sponsored by the WES and officered and manned by many key engineers of the Hydraulics Division, was called into active duty in August 1950. Fortson, the Division Chief, was Battalion Commander of this unit and was absent from WES on this military action from August 1950 to June 1952; Fenwick served as Division Chief, in a dual capacity, during that period. Dewey, an officer of this same unit, also left in August 1950 and H. C. McGee, who had been Dewey's assistant on the Mississippi Basin model, served as Chief of that Branch until Dewey's return to that position in the summer of 1952. The Division organization during these absences is shown on the chart dated 15 January 1951.

22. Many other key engineers of the Hydraulics Division were also with the 434th in the Korean War. However, one additional Branch was added during this period. On 1 July 1951 (see chart of that date) the Hydraulic Analysis Branch was added to the Division; Chief of this Branch was F. B. Campbell, a widely experienced hydraulic engineer transferred from the Omaha District. In the latter part of 1952, Dewey resigned from his position as Chief of the Mississippi Basin Model Branch and departed from the WES, whereupon this Branch was abolished and established as a section of the Rivers and Harbors Branch. The resulting Hydraulics Division organization (chart dated 1 February 1953) then remained unchanged during the next ten years or so, until early in 1962 when the Nuclear Weapons Effects Branch was established with G. L. Arbuthnot as Chief of the Branch (chart dated 1 July 1962).

23. In July 1963, the Hydraulics Division was reorganized to provide more specialized and functional branches, as shown on the chart dated 1 August 1963. Fenwick, who had been Chief of the Rivers and Harbors Branch since its formation in 1946, became Assistant Chief of the Division (remaining in that position until his retirement from the Federal Service in December 1965). This old Branch was abolished and split into two new branches: the Waterways Branch under Franco, who had worked on sedimentation and other river problems since his arrival at the WES in April 1933 (except for military duty during World War II and the Korean War); and the Estuaries Branch under H. B. Simmons, who had been concerned with estuarine

problems since his arrival at WES in February 1940. Brown, Chief of the Hydrodynamics Branch since its formation in 1946, left the Division to become Chief of the Nuclear Weapons Effects Division, which had had its beginning under Brown as a section of his Hydrodynamics Branch. This old Branch was abolished and split into two new branches: the Structures Branch under T. E. Murphy, who had been concerned with hydraulic structure problems since the spring of 1936 (except for military duty during World War II and the Korean War); and the Water Waves Branch under R. Y. Hudson, who had worked on wave action problems since his arrival at WES in June 1937. The Hydraulic Analysis Branch was retained, and Campbell held the dual position of Chief of this Branch and Special Assistant to the Division Chief for the hydraulic research program of the Division (until his retirement from the Federal Service in June 1967). E. B. Pickett, who had been Chief of the "Prototype Section" of the Hydraulic Analysis Branch since 1957, became Chief of the Branch in September 1967.

24. The titles of the five branches of the Hydraulics Division connote the several specialized fields of hydraulics into which the work of the Division falls. Each branch has in hand research as well as investigations of specific problems. In the paragraphs to follow, the development of the technological specialty of each branch will be epitomized.

Waterways Branch

25. Fluvial hydraulics is the specialty field of the Waterways Branch, Chief of which is John J. Franco, wherein the principal laboratory tools are the fixed-bed model and the movable-bed model.

26. The fixed-bed model, wherein the configuration of the river channels and its overbank flow areas are fixed in cement mortar to conform to the pertinent hydrographic and topographic surveys, is the earliest type of model built at WES. It has continued in use on problems in river regulation and improvement.

27. In application to flood-control studies, where data are sought on the development of flow lines, the determination of channel and floodway capacities, and the effects of levee changes, the fixed-bed model is usually built with a vertical scale distorted with respect to the horizontal scale. Such recourse provides a means of reproducing the vast areas usually involved without compromise in the accuracy of the results sought. The prominent example of this type of model at WES is the Mississippi Basin model, which is treated separately at the end of this appendix.

28. Navigation studies to which fixed-bed models are applicable require the reproduction of the complete pattern of current directions and strengths. Thus, a natural scale must be maintained. Extensive use of this type of model has been made over the years in the study of arrangements of locks and dams, and much has been contributed thereby to the design of navigation structures on the Alabama, Arkansas, Tombigbee, Chattahoochee, Ouachita, Ohio, and Monongahela Rivers.

29. A valuable adjunct to the application of fixed-bed models to navigation studies is a model vessel representing the towboat, lake steamer, or ship typical of the prototype vessel concerned. Starting as simple, unpowered hulls pushed with a stick, these model vessels are now battery-powered and remote-controlled by radio to provide all significant features of operation.

30. The movable-bed model, wherein the channel bed is molded in a material susceptible of movement under flow action, is used in studies of channel development and stabilization. Initially this type of model was designed for the use of sand as a bed material. The consequent high scale distortion, steep side slopes, and formation of riffles suggested the advantage of a lighter bed material. The most practical material found was crushed coal, which has been in general use since about 1936. Improvements in techniques and procedures with movable-bed models have been realized through the use of larger scales, less distortion, and refinement of adjustment procedures.

31. Under study intermittently for the past 20 years are two phenomena having important effects on river models. One is the matter of water temperature that has been found to have an appreciable effect on flow and channel development not only in models but also in full-size streams. The other is the matter of distortion, the effects of which are determined largely by experience and judgment. It would be valuable to establish definite, permissible degrees of distortion.

32. In 1963, an investigation was undertaken to determine factors affecting the performance of dikes used for the regulation and improvement of alluvial streams and to develop parameters for use in the design of dikes and dike systems. To date, the results of this study have indicated how the effectiveness of the dikes could be increased and construction cost reduced by use of the stepped-down principle and by the use of vane-type dikes in connection with the spur dikes under certain conditions. The stepped-down principle and the vane-type dikes have been adopted for construction in the several reaches of the Mississippi River and in the Apalachicola River with a considerable reduction in cost over the original plans. The study has also resulted in the development of a method for evaluating the performance of these structures.

Estuaries Branch

33. Tidal hydraulics is the specialty field of the Estuaries Branch, headed by Henry B. Simmons, wherein the principal laboratory tool is the tidal model, that is most frequently of the fixed-bed type but on occasion is provided with a movable bed.

34. The first hydraulic model at the WES that required simulation of tides and tidal currents was constructed in 1933. The rise and fall of the tide, and the reversing tidal currents, were reproduced approximately by manual manipulation of valves installed in pumped inflow and gravity outflow lines connected to the two ends of the

model. In 1937, mechanized submerged weirs were developed for control of tidal elevations and directions and velocities of tidal currents; these weirs were programmed by a special electromechanical control system that resulted in a major improvement in the accuracy with which tidal phenomena could be reproduced in hydraulic models. In 1939, mechanized rising-stem valves were substituted for the mechanized weirs, resulting in a simplification of the adjustment of tidal phenomena in models and a further improvement in accuracy of tidal reproduction. The electromechanical control system for programming the valves was also improved significantly at about this same time, and this basic equipment is still used to reproduce tidal phenomena in models.

35. Techniques and procedures for movable-bed shoaling studies in tidal models were developed in 1935 and have been progressively improved and refined to the present time. Techniques for conducting shoaling studies in fixed-bed models, through the use of lightweight granular materials injected into the model, were developed in about 1937. The material used to simulate prototype sediment in a given model is selected, from the results of empirical tests, as being that material which moves and deposits under the influence of the model currents in the closest possible approximation of the movement and deposition of the natural materials under the influence of the prototype currents. Techniques and procedures for such studies are being constantly improved with the availability of new materials and more reliable information as to shoaling phenomena in the prototype. Both movable-bed and fixed-bed shoaling studies yield qualitative rather than quantitative results, although the results of follow-up confirmation studies have shown that, in most instances, model predictions of changes in shoaling rates and patterns have been very accurate.

36. The significance of density currents on hydraulic and shoaling phenomena in estuaries was recognized in the late 1930's, and techniques for operating estuary models with both salt and fresh water were developed in the early 1940's by Tiffany, Fenwick, and Simmons so that such effects could be reproduced. A required salinity scale of unity was determined through control tests conducted in flumes at the WES, and this scale relation was subsequently confirmed through exhaustive flume and analytical studies by the National Bureau of Standards. Subsequent refinements in this technique involved development of a special type of roughness for estuary models, consisting of thin metal strips mounted vertically in the bed of the model. Proper adjustment of this special roughness made it possible to reproduce with a high degree of accuracy the lateral and vertical distribution of current velocities and salinities throughout the saline regions of estuaries, and having attained such reproduction, it was found that the response of saltwater intrusion to changes in tides and freshwater discharge was also reproduced with a high degree of accuracy. These developments have made it possible to reproduce and study hydraulic and salinity phenomena in estuary models in a quantitative sense.

37. Techniques and instrumentation for conducting dispersion, diffusion, and flushing experiments in estuary models were first developed in 1952. Subsequent

refinements were made in these techniques and procedures, leading to the present practice of using fluorescent dyes as tracers and highly accurate fluorometers for dye detection and analysis. Many experiments of this nature have been made in estuary models during the past 10 years, and much has been learned from these experiments as to the complex nature of dispersion, diffusion, and flushing phenomena.

38. Techniques for conducting thermal diffusion studies in estuary models were developed in 1966, and these techniques are being refined and improved very rapidly. The problem of thermal diffusion has been greatly magnified in recent years as a result of construction and/or design of large steam-generating plants that use estuaries as a source of cooling water; and hydraulic models contribute much toward defining the effects of such plants on estuaries as a whole, as well as in the specific design of intake and discharge facilities to minimize recirculation of heat.

Structures Branch

39. Structural hydraulics is the specialty field of the Structures Branch, of which Thomas E. Murphy is Chief, wherein the subjects under study are the appurtenances of dams, including spillways, stilling basins, conduits, and locks. The principal laboratory tool is a natural-scale model of the structure under study, fabricated of wood, metal, plastics, and/or concrete in such detail as the problem requires.

40. Early model studies were conducted according to techniques developed in Europe and at university laboratories. However, as the young staff gained experience, new model techniques were developed. Further, in its consulting role the staff has had an ever-increasing influence on the design of hydraulic structures.

41. In 1946, forces on vertical lift gates for Garrison and Ft. Randall Dams were studied in a model in which a coil spring was used to simulate the elastic properties of the cables by which the prototype gate was to be suspended. This technique made the model data much more meaningful and since has been adopted in many forms.

42. In 1954, the Airfields Branch, Military Construction Division, OCE, requested WES to make an analysis of surface runoff data collected at test strips in Santa Monica, California. This was the beginning for the Structures Branch of what has been a continuing program of investigations of drainage facilities at military installations.

43. Initial models of conduits were conducted according to Froude's Law and were constructed at a scale of 1:25, because it was considered that the plastic used for model construction would at this scale represent the roughness of the prototype concrete. However, field measurements at high Reynolds number revealed friction factors less than had been anticipated. Thus, it became apparent that the discrepancy in Reynolds number between the model and the prototype resulted in friction losses in the model greater than corresponding losses in the prototype. A technique by

which the model conduit is shortened to compensate for the greater friction losses was developed and first applied to a model of the outlet conduit for Abiquiu Dam during 1955. This procedure has been used for all subsequent conduit models.

44. The stability of riprap adjacent to a hydraulic structure first was studied during 1955 in a model of the Old River Low-Sill Control Structure. Techniques for study of riprap stability have progressively been improved. Much work remains to be done in development of design procedures for riprap. However, the staff of the Structures Branch, in its capacity as a consultant, has exerted appreciable influence on riprap design. For instance, its advocacy of a preformed enlargement of the riprap channel immediately adjacent to a stilling basin is gaining widespread acceptance.

45. Primary responsibility for development of designs of the filling and emptying systems for locks was transferred from the St. Paul District to WES in 1958. A filling and emptying system (bottom longitudinal system) basically different from any previously used in a Corps lock was model-tested in 1962 for the Millers Ferry Lock. This system proved so successful that it has been adopted for other locks, and it is likely to be used in a majority of the medium and high lift locks to be constructed in the future. Basic principles involved in this system had been developed and applied in Europe, but it largely was due to the promotional efforts of the Structures Branch that the Mobile District agreed to deviate from old methods and investigate this system.

46. Prompted by anticipation of future work, an in-house research project was started in 1967 to develop model techniques and instrumentation for study of selective withdrawal of water of the desired temperature or quality from stratified reservoirs. Prior to the end of 1967, requests for such studies were received and the studies were undertaken. Basic research on selective withdrawal is being conducted at several installations, but as far as is known, no other installation is making relatively large-scale studies of specific projects.

Water Waves Branch

47. Surface wave action in water is the specialty field of the Water Waves Branch, wherein the principal laboratory tools are the fixed-bed harbor model and the testing flume. Robert Y. Hudson is Chief of the Branch.

48. Harbor wave-action models are three-dimensional models involving both short-period wind waves and long-period, surge-type waves. Theoretical and experimental research studies have also been made to determine the design features of models for use in investigating the problems of harbors that are subjected to catastrophic waves known as tsunamis, or seismic sea waves, with periods from about 5 to 30 min. Harbor wave-action models are usually conducted to determine the best alignments and lengths of breakwaters; locations, shapes, and widths of navigation

openings; locations and lengths of wave absorbers; and the effects of contemplated dredge cuts or fills or any other proposed changes in boundary conditions that might affect the mooring and navigation conditions of vessels in the harbor area.

49. Breakwater and wave absorber models are usually two-dimensional models, but they are sometimes three-dimensional models, used to determine the optimum design of breakwaters for stability, the efficient use of available construction materials and equipment, and the desired reflection, transmission, and overtopping characteristics. Also, tests are conducted on these types of models to obtain the required stability and wave-absorption characteristics of wave absorbers.

50. A few of the more noteworthy achievements of the waves group include:

a. The testing of cellular caisson breakwaters for the Normandy Invasion of France in World War II.

b. Tests of wave and current conditions in the entrance to the Midway Island Naval Base, near the end of World War II.

c. The development of a testing procedure for conducting stability tests of rubble-mound breakwaters and the derivation of a stability formula, which is used throughout the Corps of Engineers and worldwide, for the design of rubble-mound breakwaters with cover layers composed of either quarry rock or molded concrete armor units of the types known as cubes, hexapods, quadripods, tribars, tetrapods, and tetrahedrons.

d. The development of testing procedures for the determination of the largest breaking and nonbreaking waves that can attack rubble-mound breakwaters.

e. The development of testing procedures for the performing of model studies in which the problem involves the protection of harbors and adjacent shoreline from the effects of tsunamis, and model studies in which the problem involves the protection of moored ships from surge caused by long-period waves.

f. The design of a pneumatic wave generator and the conduct of tests to determine the stability of rubble-mound barriers subjected to the attack of borelike waves generated in harbors due to tsunamis.

51. At the present time, there is a research program under way with investigations concerning wave forces on vertical-wall breakwaters due to breaking waves, general design data for rubble-mound breakwaters, design of floating breakwaters, the protection of marinas from wave action, and the effects of model scale on the accuracy of model data when the tests involve reproduction of wave reflection, absorption, and transmission characteristics of rubble breakwaters and wave absorbers.

Hydraulic Analysis Branch

52. The development and dissemination of hydraulic design data and procedures is the specialty field of the Hydraulic Analysis Branch, Chief of which is Ellis B. Pickett, wherein office analysis and field investigations are the principal activities. In addition, some basic laboratory research is conducted in flumes and tanks.

53. The activities of the Branch ultimately manifest themselves in the publication of Hydraulic Design Criteria, a loose-leaf design manual which is kept up-to-date by the continuous addition of new material and the revision of existing material as additional data become available and new theories and procedures are evolved. The purpose of this publication is threefold: (a) the dissemination of the most up-to-date hydraulic design criteria to permit the design of efficient and economical hydraulic structures, (b) the development of design aids to expedite design study and to save valuable engineering time, thereby permitting comparative design investigations, and (c) better flow regulation by providing discharge coefficient data for control valves and gates. The initial issue of Hydraulic Design Criteria was distributed in 1952 and consisted of 11 charts and 5 explanatory sheets. A total of 250 copies were printed. To date, 14 issues consisting of over 230 charts and 140 pages of text have been published. At the present time, 2500 copies of each issue are being reproduced with over 500 copies distributed to Corps of Engineers, other Federal agencies, consultants, contributors, and universities. Over 1000 copies have been purchased by private individual and engineering concerns. Domestic and foreign demand for Hydraulic Design Criteria increases at a rate of about 200 copies per year.

54. Field investigations obtain experimental results on problems that cannot be solved by laboratory tests. Specifically, the purpose is to coordinate the hydraulic prototype testing program of the Corps in order to ensure complete coverage of needed testing, prevent unnecessary duplication of testing facilities and tests, recommend instrument installations at projects where physical and hydraulic conditions will be suitable for obtaining data, and investigate hydraulic performance. Assistance is given to districts in planning and making hydraulic prototype tests, including: planning and design of test facilities, making available personnel and equipment for tests, and analyzing data and preparing reports. The ultimate objective is to obtain and disseminate information that will permit more economical construction and satisfactory operation of the Corps projects.

55. Measurements are made of average and fluctuating pressures, discharge, average and fluctuating velocities, water depth and level, air demand, force, torque, displacement, vibration, and cavitation. These measurements are made for tunnels, conduits, siphons, spillways, stilling basins, channels, gates, and valves. The data have been furnished in informal and formal reports and used in the development of Hydraulic Design Criteria. Special instruments developed or utilized for prototype tests include high-velocity pitot piers, struts, and probes; special waterproof adaptors for many kinds of transducers; hot-film field anemometers; acoustic flowmeters; and surface-roughness analyzing equipment. Valuable data also have been recorded in still and motion pictures and on audio records. Radioactive tracers have been used to ascertain the movement of sediments in estuarine channels.

56. Prototype testing has become increasingly complex with emphasis on the

dynamic behavior of a structure as indicated by fluctuating pressures, forces, and vibrations. This has required extensive use of electrical measuring and recording equipment. The design of testing equipment to operate satisfactorily in high-head structures is a major technical problem. Prototype tests require equipment that can be subjected to full-scale pressures, forces, and vibration and generally adverse environments. The accurate measurement of flow through an outlet works and hydroelectric power plants has not been completely satisfactory in the past. Development of an acoustic flowmeter has been actively pursued with the objective of a very accurate discharge-measuring instrument that will not project into the flow. Rod-type equipment was evaluated in a rectangular sluice at Sutton Dam and point-type units have been successfully tested in a penstock at Oahe Dam. The point-type flowmeter system is installed at Summersville Dam.

Mississippi Basin Model

57. The Mississippi Basin Model at the Jackson Installation is the largest in the world and the largest single project ever undertaken at WES. It was initiated by MG Eugene Reybold, Chief of Engineers, in 1943 with prisoner-of-war labor on the reservation near Clinton, Mississippi. The Secretary of War, in 1945, established a Mississippi Basin Model Board, with responsibility for determining policies and programs for subsequent development and operation of the model. Construction of the model proper was started in 1947 and completed in 1966. The completed model is a reproduction to scale of most of the Mississippi River and its major tributaries. The model was constructed based on priorities established by the Board; the upper reach of the Mississippi River and tributaries and the Mississippi River reach below Baton Rouge, Louisiana, were eliminated when it was determined that no general problems would exist in those reaches.

58. The original and primary purpose of the model was to develop plans for the coordinated operation of the reservoir system in the Mississippi Basin; this purpose has been expanded to include investigations for planning, design, and coordinated operation of all flood-control works in the Basin. The model offers a means of integrating rapidly and automatically the results of any probable sequences and combinations of floods from the Mississippi River and its tributaries, and is used to assist in obtaining reliable answers to many local and general problems not readily susceptible of solutions by analytical procedures.

59. Although the model was not completed until 1966, specific reaches were placed in operation and tested as soon as completed. The completed portion of the model was used to aid in flood-fighting activities during the great flood of April 1952 on the Missouri River. Its use aided materially in delineating areas to be flooded, in locating critical points on levees, and by assisting in the timings of evacuations of areas that were later flooded. The information thus furnished from

the model was a major factor in preventing more than $65,000,000 in damages.

60. In fiscal year 1959, a start on the overall objectives of the model was initiated on the completed portion of the model above Memphis, Tennessee. Beginning in fiscal year 1966, the portion of the model below Memphis was available for testing purposes and use of the full model was possible.

61. The total cost of the model through June 1956 was prorated to flood-control projects within the area covered by the overall model limits and assessed as an engineering expense against flood-control projects under construction at the time throughout the Basin. Subsequently, funds for the model were provided by direct appropriations by Congress. The cost of model construction was about $11,250,000.

Potamology in the Hydraulics Division

62. Comprehensive research on the channel stabilization of the Mississippi River was undertaken in 1946 under the designation of "Potamology Investigations." However, there had been studies in potamology, i.e. the science of rivers, from the earliest years of the WES.

"Directive energy" studies

63. From 1932 to 1935, "directive energy" studies were conducted in pursuit of the answer to the question posed by BG H. B. Ferguson, President, MRC, as to how long should the crossing reach be. Experiments were conducted in an outdoor flume filled with sand. A predetermined slope of the valley was molded for each test, and a straight channel was molded through the center of the flume. Constant discharges were supplied and the channel was allowed to develop its own meander belt. Sponsorship was terminated before a specific answer to the General's question was deduced. However, a major qualitative conclusion of this investigation was that the greater the rate at which bed load was supplied to the first bend, the greater the size of the bends and the more rapid the rate at which they developed.

Measurements of materials in transport in the Mississippi River

64. Probably the most comprehensive and reliable measurements of sediment load in the Mississippi River itself were made in 1937-1938 at Mayersville, Mississippi, and in 1938 in the vicinity of the Head of the Passes. The quantity of materials being transported by the Mississippi River is of basic significance to most if not all of the problems related to the stabilization of the river for both navigation and flood-control purposes. A great many measurements have been made of the fine sediment carried in suspension, but no accurate means have been devised for measuring the amount of coarse-grained material being carried immediately adjacent to the bottom of the river. The Mayersville observations of sediment load (including the sand component) included only that portion which was in suspension in the water.

The maximum rate of measured sand transport, just before the crest of the 1937 flood, was approximately 1,870,000 cu yd per day. This figure is still impressive in that it includes only that part of the sand load which was in suspension and could be caught in the sediment traps that were used, and did not include the major portion of what is commonly considered bed load.

Investigation of the
meandering of model streams

65. During the period from July 1940 to the fall of 1941, an investigation similar to the "directive energy" studies of 1932 to 1935 was conducted for the Mississippi River Commission. The specific stated purposes of this investigation were: (a) to obtain specific data on the natural tendencies of a model stream in regard to the developing and maintaining of a definite meander pattern, and (b) to study methods of controlling and directing these natural tendencies in connection with the solution of various practical river problems. This study was conducted in a large flume containing crushed coal as the movable-bed material. Operation of this model was somewhat similar to that of the "directive energy" model, with the principal exception that the model was operated for each test through a hydrograph representing low, intermediate, and high stages (including overbank stages). Also, steps were taken to provide more cohesiveness to the material in the streambanks and overbanks than in the material in the streambed.

66. Although the model had a limitation in that the amount of bed material the model stream was able to move was of the same order of magnitude as the amount of material supplied to the model stream from its caving banks, this investigation was a landmark in research on channel stabilization in that it developed or confirmed much information of basic importance. The study was terminated abruptly in December 1941, immediately following Pearl Harbor and the entry of the United States into World War II (the engineers in charge were transferred to the Lower Mississippi Valley Division and assigned to military construction activities). However, this investigation can be said to be the foundation upon which the next channel stabilization research program was founded.

Study of the meander-
ing of alluvial rivers

67. The most extensive laboratory study of the meandering of alluvial rivers was conducted at the WES from 1942 to 1944 under the authorization and direct supervision of the President of the Mississippi River Commission. This study followed shortly after the interruption of the investigation meandering of model streams, and can be said to have been undertaken partly as the result of the findings of that earlier investigation. This study resulted in the publication of the report Laboratory Study of the Meandering of Alluvial Rivers, by J. F. Friedkin, Captain, Corps of Engineers. This report was widely distributed, and has since been referred to by investigators all over the world who are interested in alluvial river

development. The 1944 congressionally authorized project for bank stabilization on, and a 12-ft navigation channel in the Mississippi River was based to a large extent on the findings of this study.

68. The scope of the study included the determination of: first, the basic principles of meandering rivers; second, the principles involved as to the effects of stabilizing the caving banks of a meandering river. The studies were carried out in several laboratory rivers and in several types of bed materials including crushed coal, sand, and silt. As in the case of the earlier and similar investigations, the several basic factors affecting stream migration were individually and carefully controlled. These included the rate of discharge, the axial slope of the valley, the quantity of bed load added to the upstream end of the model rivers, the type of bed material, and the type and cohesiveness of the bank materials. General principles were developed qualitatively, relating to the slope, and bed material in motion.

Potamology investigations

69. As has been stated, comprehensive research on the channel stabilization of the Mississippi was undertaken in 1946 under the designation of "Potamology Investigations." The hydraulics phase of the potamology investigations was instituted in 1947 and continued actively through 1951 at an average rate of about $280,000 per year for that four-year period. The main objectives of the hydraulic investigations, as arrived at in conferences between the interested offices at the beginning of the original program, were: (a) to study the meandering tendencies of the Mississippi River with a view to the development of a model and model operating technique that can be used to predict future changes within any specific reach of the Mississippi River; (b) to determine the nature of revetment failures, their causes, and methods of preventing such failures; (c) to study and develop methods of channel stabilization by means other than the use of revetment; and (d) to develop and test comprehensive plans for the improvement of specific troublesome reaches of the Mississippi River. Work in the soils phase accomplished under this program is summarized elsewhere. Accomplishments in the hydraulics phase are briefed in the paragraphs to follow.

Channel meandering model study

70. In order to develop a model technique for the study and prediction of future meander changes within specific troublesome reaches of the Mississippi River, it was necessary to devise means whereby model bed and bank materials reacted to erosion, transportation, and deposition in manners similar to those phenomena in the river itself. A technique was obtained through refinement of the WES practice for modeling bed movement with crushed coal (in which banks are customarily fixed in concrete) by reproducing the banks in coal rendered resistant to erosion by the admixture of plaster. As the banks sloughed in proper scale, the plaster washed away leaving the coal as a loose, granular bed material, The technique thus developed is available for application to any troublesome reach of the river as the need arises.

Nature, causes, and preventions of revetment failures

71. The hydraulic investigations into the nature of revetment failures, their causes, and methods of preventing such failures, took several tacks. In essence, these were:

a. Revetment model studies. The difficulty of evaluating the performance of revetment in the field suggested an investigation in models, wherein bed and banks would be erodible and revetment would be reproduced to scales of weight and strength as well as dimension. A preliminary study to a natural scale of 1 to 50 was conducted in an existing flume. Articulated concrete revetment, mass sand-asphalt revetment, groins, retards, and concrete blocks were molded. These preliminary tests were considered sufficiently rewarding to justify the construction of a flume to accommodate a complete bend of the river, including the opposing point bar and the crossings above and below, as well as the concave bank supporting the revetment, the latter being the extent of the capabilities of the existing flume used in the initial preliminary tests. Accordingly, a flume was constructed, 600 ft long, 125 ft wide, and from 2-1/2 to 3-1/2 ft deep, which permitted the reproduction, to a linear scale ratio in the order of 1 to 50, of an entire bend of the Mississippi River. The Reid-Bedford reach was modeled and successfully verified to known regimen changes with a scale of 1 to 60. The investigation was suspended without the undertaking of developmental studies of revetment practices. However, this flume was used extensively for several months by engineers of the Mississippi River Commission and the Vicksburg District for rough tests of various schemes for regulation of the Millers Bend reach and other areas.

b. Hydrographic and hydraulic field investigations. Although means were not at hand for directly observing the performance of revetment in the field, it was none the less desirable to obtain and analyze hydrographic and hydraulic data on various reaches of the Mississippi River with a view to isolating factors affecting revetment and bank stability. Reid-Bedford Bend, False Point, and Bauxippi-Wyanoke Bend were selected as appropriate sections for surveillance, these being revetment sites which were, respectively, a relatively new unstable revetment where active caving had occurred and where failures were considered possible, a relatively new stable revetment where no major changes in river regimen were expected, and an old stable revetment where a major change in basic river conditions was anticipated. An examination was conducted of all data available on the histories of the areas, the results of soils and geology investigations, the methods used in placing the revetments, and prior hydrographic surveys. The field investigations undertaken in hydrography included general surveys of the reaches between the crossings above and below the revetments and detailed surveys of the revetted areas. The investigations in hydraulics included float observations and velocity measurements at various stages to determine the direction of current impingement, the range and magnitude of velocities, and the velocity distribution. The field investigations persisted over the period from January 1947 to May 1951. No major failures occurred at any of the three sites under observation during the period covered by the investigations. Thus, there was denied the opportunity to draw definite conclusions as to the nature and causes of failures. However, the reports published on the investigations document in detail the seasonally changing characteristics of the Mississippi River and make available a wealth of information which is valuable within itself and also for correlation with future studies.

c. Turbulence investigations. The dynamic pattern of flow associated with revetment under heavy attack suggested that pulsations in pressure within the river could affect the stability of revetment and its supporting bank. Measurements were made of the turbulence in the Mississippi River at Reid-Bedford, Millers, and Yellow Bends with a hydrodynamic pulsimeter fitted with a pressure cell and a velocity meter. Momentary point fluctuations of pressure which exceeded the submerged unit weight of concrete revetment were observed.

Channel stabilization by means other than revetment

72. It was contemplated that the study and development of methods of channel stabilization by means other than the use of revetment would consist of the study of other existing methods, such as groins, retards, and dredging, and the development of possible new methods. This phase did not progress beyond the preliminary activities referred to above.

Appendix VI
HISTORY OF THE SOILS DIVISION

Origin and Early Development

1. While the WES was established as a hydraulic laboratory, knowledge of soils was early recognized as an associated need. In about 1932, a small group of technicians began conducting mechanical analyses of samples of bed load and sediment from the Mississippi River. The work was soon extended to analyses of soils being considered for levee construction. Among the earliest workers in this new field were William J. Roland, Spencer J. Powers, and Victor K. Wagner. About this time the first students of Profs. Karl Terzaghi and Arthur Casagrande completed courses under these eminent teachers and engineers in the then new field of soil mechanics. Among early graduates was Spencer J. Buchanan who became associated with the WES in late 1933 and was placed in charge of the work in the field of soil mechanics. This appears to be the first time that the soils work group was recognized as an organizational element of the WES rather than being a small group of technicians who devoted part-time effort to soil testing.

2. The work steadily increased, and J. Bres Eustis and Frederick A. Harris were added to the staff in 1934. It was also at about this time that a simple wooden frame building about 40x60 was constructed to house the soils laboratory. About 1936, William L. Wells, another of Prof. Terzaghi's students, joined the staff. Also, a Soils Research Center was established with Robert M. German in charge. The early background of the Soils and Hydraulic Research Centers is covered in other parts of this History; however, the presence of the Soils Research Center is worthy of noting here separately because of its importance with relation to the Soil Mechanics programs. It should be remembered that at this time, 1936 and 1937, there were no texts available on soil mechanics. Virtually all information on soil mechanics practice and research appeared in the form of papers in technical periodicals, especially those from Germany and Switzerland. The translation of articles of important work in the field of soil mechanics appearing in these foreign periodicals was a major mission of the Research Center, and information obtained by these means was of inestimable value in all phases of work involving soils and soil mechanics.

3. It is evident, from examination of the organization chart dated 1 March 1937, that the Soils Research group was only a small part of the overall WES activities. Growing pains were just beginning, however, and technicians were continually borrowed from the pool of engineering aides shown under the Personnel Assistant on the referenced chart. A number of these engineering aides, after being borrowed for the soils laboratory for a number of times, were finally given permanent assignments with the soils group even though their assigned duties were frequently

interrupted because of the large personnel requirements in the operation of the famous hydraulic model of the lower Mississippi River.

4. Beginning with the 1936-1937 period, the staff of the Soils Research group increased steadily. Among the employees assigned about this time were A. A. Maxwell, A. L. Mathews, G. M. Peterson, and E. L. Campbell. The soils group at this time was known as Soils Research, which was headed by Spencer J. Buchanan, with a test (laboratory) section and a research center headed by W. L. Wells and R. M. German, respectively.

5. The soils laboratory was equipped to perform sieve analyses, hydrometer analyses, Atterberg limits tests, consolidation tests, direct shear tests, water analyses, and simple chemical tests as required. As this was, as far as is known, the only soils testing laboratory in the Corps of Engineers (CE) at this time with the capabilities stated, a considerable quantity of work began to be done for other CE divisions and districts.

6. A truck-mounted drill rig was obtained and soon afterward field operations became a significant part of the work. The field work was under the direct charge of W. J. Rowland with various crews assembled as required. Soon, A. L. Mathews became Mr. Rowland's assistant and was spending more time in the field than in the laboratory. With increasing laboratory and field capabilities, the work load and diversity of work continued to grow and numerous cases arose whereby assistance to other offices in design problems was provided in addition to the already established field and laboratory assistance.

7. An early landmark in this type of work was the construction in 1939 of a levee near Pendleton, Louisiana, by the Vicksburg District. It was necessary for the levee to cross an area where the presence of a soft clay presented a problem. It was obvious from laboratory test results that this soft material would not support the levee and must be moved or displaced in some way. It was determined that the levee would be overbuilt through this stretch and the soft material displaced by the weight of the levee fill. W. L. Wells devised a scheme for instrumenting this foundation and observing its behavior during the process of overloading and failure. A report on this deliberate foundation failure was later prepared by CPT K. E. Fields and Mr. Wells, and in effect, it verified the validity of the wedge method of stability analyses.

8. A unique laboratory investigation was initiated to establish the lateral pressure exerted by mining debris on impounding structures. In this study, the lateral forces against a vertical surface during placement and consolidation of the debris were measured. This was one of the first of such studies to be undertaken. It was performed for the California Debris Commission.

9. About 1938, the first triaxial compression test equipment was obtained. It was shop-made of brass following a design developed by Prof. Arthur Casagrande to test a sample 1.4 in. in diameter. This first machine attracted considerable

interest because the volume change in a sand specimen could be readily observed by means of a manometer connected to the interior of a saturated sample. The critical void ratio concept was also the subject of a comprehensive series of tests with direct shear apparatus conducted by A. L. Mathews. It was necessary for our shops to go virtually into mass production of triaxial test machines to meet the testing requirements resulting from the construction of Sardis Dam, which was a hydraulic-fill structure with sand shells, and to supply other CE laboratories being activated with such equipment. Following the Fort Peck Dam slide failure, about 20 of the triaxial machines operating on a seven-day, frequently two-shift basis were required to perform the necessary tests on the shell materials used in the reconstruction of the dam. In fact, the testing schedule became so heavy that many of the machines were sent to Fort Peck and operated at the site. C. L. Horn from the WES soils group accompanied the equipment to Fort Peck and supervised the conduct of the tests there.

10. A logical step in the development of a new field such as soil mechanics was the observation of prototype structures to determine if they were performing as expected. This required, of course, the development of suitable instrumentation such as hydrostatic and earth pressure cells. In the late 1930's and early 1940's, significant effort was devoted to the development of such instrumentation. Dr. J. O. Osterberg, employed at the WES for several years, was a major contributor to the design of the WES pressure cell, and R. A. Ford and W. H. Rodgers were instrumental in developing machining and welding techniques for the fabrication of the pressure cells. When the first cells were fabricated, the neatly packaged and mounted SR-4 type and foil type resistance gages were not available as we know them today. The gage wire was received on spools and the gage actually built on the metal of the cell with glue, tweezers, handrests, magnifying glasses, and an enormous amount of patience. The gaged area was then covered with bakelite and baked. This work was later (1942) followed up under W. J. Turnbull by the formation of a consultant group among whose members were Prof. D. W. Taylor and R. A. Carlson. This was probably the first formal consulting board at WES.

11. In conjunction with field exploration programs, a capability for the conduct of refraction-type seismic tests and electrical resistivity tests was established with W. R. Perret in charge. Preliminary site investigations were made by seismic methods at a number of damsites in the Ozark highlands in Arkansas and other areas.

World War II Era

12. Rapid changes occurred in the Soils Division over the period from 1940 to 1945. World War II began to have an effect as individual reservists and National Guard units began to be called into the service. Mr. Buchanan was transferred to

the Mississippi River Commission (MRC) in October 1940, and W. L. Wells assumed the responsibilities for what was then called the Soil Mechanics Laboratory. At about this time, the Soil Mechanics Research Center was transferred out of the Soil Mechanics Laboratory to the WES Research Center, which was responsible for work in both the fields of soils and hydraulics. Samuel Shulits was chief of the Research Center and Mr. German continued as chief of the Soil Mechanics portion of this center.

13. During the early 1940's, the Soils Laboratory participated in the Cooperative Triaxial Shear Research Program of the CE together with Harvard University and the Massachusetts Institute of Technology. Completion of this work in 1947 resulted in a major advancement in the technique and analysis of triaxial shear testing by the CE.

14. Following Mr. Wells' call to active duty, C. R. Horn took over the Soil Mechanics Laboratory for a short period of time pending the arrival of W. J. Turnbull in late 1941. Mr. Turnbull was placed in charge of the Soil Mechanics Laboratory and has remained in this position to the present time. The unusual growth and success of the Soils Division are in a large part the result of Mr. Turnbull's guidance and untiring efforts. In late 1942 W. H. Jervis was transferred from the Vicksburg District to WES and placed in charge of the Embankment and Foundation Branch, and in late 1943 Keith Boyd joined the Embankment, Foundation, and Pavement Division as chief of the Flexible Pavement Branch.

15. The effects of the war became increasingly more evident. Construction and design problems arose immediately in connection with the numerous airfields being constructed throughout the United States. Of immediate concern was the depth of cover required over airfield subsurface drainage systems. Increased wheel loads of the military aircraft required careful placement of underground drainage systems to ensure that they would perform satisfactorily under the imposed loadings. A comprehensive test program under A. A. Maxwell was initiated in which corrugated metal pipe, plain and reinforced concrete pipe, and an expedient type hexagonal pipe made of wood staves were tested to failure at depths from 1 to about 6 ft. Data from these tests were included in early designs almost as rapidly as the tests could be run. This test was a forerunner of many such tests by other organizations in determining the bearing capacity of culvert pipe.

16. The design of runway and taxiway pavements was of utmost concern. Two laboratory facilities were established in 1943 within the CE to handle this problem, namely the Flexible and Rigid Pavement Laboratories at the WES and the Ohio River Division Laboratory at Mariemont, Cincinnati, Ohio. The Flexible Pavement Laboratory was established as a part of the Soil Mechanics Laboratory at the WES and the title of the Soil Mechanics Laboratory was changed to Embankment, Foundation, and Pavement Division with Mr. Turnbull as chief.

17. Due to the great need, time did not permit the development of a new

method for the design of flexible pavements that would encompass the then-current highway experience and the much greater wheel loadings of the military aircraft. The problem thus was to select an existing method that could be extended to serve military needs. This requirement dictated that any test procedure and testing equipment be the simplest possible that would meet the needs for design and evaluation of pavements. The procedures developed by the late O. J. Porter of the California Department of Highways had been eminently successful for highway design purposes. This procedure was critically examined along with all others current at the time and was selected as being the most appropriate for military purposes. The basic strength parameter in this design procedure was called the California Bearing Ratio (CBR). The CBR design procedure, after many modifications, is still in use today by the CE.

18. The early phases of the use of the so-called CBR method have been reported in many places. The first step was an extrapolation of the load-depth relations established by the California Highway Department for highway loading to the heavier loadings of military aircraft. This initial extrapolation was accomplished by Prof. A. Casagrande, consultant; the late O. J. Porter of O. J. Porter and Company; and the late T. A. Middlebrooks of the OCE. The CBR method could be easily used both for design and evaluation of pavements.

19. An important in-house study on the CBR was carried out in the Embankment, Foundation, and Pavement Division in 1943 and 1944 under the immediate direction of J. B Eustis whose principal assistant in the work was J. L. McRae, the latter having joined the Soils Research group in 1938. The work consisted of an extensive study of the effects on the CBR of changes in the molding moisture and compacted density, both in the soaked and the unsoaked conditions. This research study was the early forerunner of many such studies by the CE and other organizations. One of the extremely important by-products of this study was the development of the "family of curves," which shows the full range in the strength of a remolded soil with changes in moisture and density in both the soaked and the unsoaked conditions. The family of curves and the overall CBR study represented a real breakthrough in the understanding of the behavior of soils under pavements.

20. After the selection of this method and the extrapolation to loadings of the magnitude involved with aircraft, an immediate program of validation was established. In this program, the characteristics of the pavement materials at existing selected airfields were examined. Airfields selected were those where reasonably good data as to the type aircraft and amount of traffic and the airfield performance were known. These airfields were then "designed" on paper by the CBR method and the known performance of the airfield compared to the performance that would be indicated from the design procedures used. As more evaluation data became available, modifications and adjustments were made in the basic design curves. This practice is still followed today.

21. As with the overall design of flexible pavements, the CE was faced with the necessity of developing a method and procedure of design for bituminous concrete mixes as binder and wearing courses. Again, due to the exigencies of time, there was not time to go into a detailed development program. Consequently, several methods and procedures were examined, among them the Hveem and Marshall methods. The Marshall method was selected as the most desirable procedure to study because of its simplicity. Bruce Marshall, developer of the Marshall method, was currently working for the Mississippi Highway Department, and subsequently was hired as a member of the laboratory staff of the Flexible Pavement Branch. The method has been very materially improved upon by the Flexible Pavement Laboratory staff, and in its current stage is known as the Marshall method of bituminous concrete design and is currently the CE standard procedure. As a matter of fact, it has been widely accepted by the industry.

22. During the 1943-1946 period, extensive laboratory testing of pavement design procedure was carried out, followed by comprehensive field studies in the large asphalt-stability test section. W. K. Boyd, C. R. Foster, and J. M. Griffith were closely associated with this work. Results of these studies represent another landmark development in that they played a significant roll in graduating bituminous pavement mix design from an "art," gained through long experience, to a "science" following definable behavior patterns.

23. An extremely important pnase of military engineering was begun during the early war years. This dealt with the off-road mobility or trafficability of military vehicles. Field work was accomplished in which military trucks and tracked vehicles were operated in soft soils to obtain some relation between soil strength and the amount of traffic which the soil could support before the vehicles became immobilized. The growth and development of this work was unusual. From a project status, the work grew until it constituted an entire section of the Flexible Pavement Branch. With continued growth it attained branch status in the Soils Division and eventually developed into a separate division (Mobility and Environmental) at the WES. The late O. B. Ray made major contributions to this area of military engineering. The history of this work is described in other portions of this document.

24. Another phase of military engineering work in connection with airfield expedient surfacing developed in late 1942. Military operations in the undeveloped areas of North Africa and the South Pacific generated an urgent need for the capability of rapid construction of airfields for short periods of intensive use. A crash project was assigned the Embankment, Foundation, and Pavement Division to develop new mat surfacing and determine the carrying capacity of certain existing mat and membrane materials. The work was carried on around the clock during the fall and winter of 1942-1943 under the direction of James E. Watkins. The most prominent existing mat and membrane were known respectively as "bar and rod" and

"PBS," the latter being used extensively by the British in Burma and India in the early stages of World War II. From these early tests emerged the pierced steel plank landing mat, followed by a succession of mats and membranes that are still being developed and improved; this work was the early forerunner of what was to become work for an entire branch in the Soils Division in the early 1960's.

25. For a year or so (1943) a Geology Division shows on the WES organization charts under Dr. H. N. Fisk (deceased) at Louisiana State University. In subsequent years it was transferred to the Mississippi River Commission as an off-post contract effort. A Geology Unit in the Soils Division is not shown again until 1948. During the time interval between 1941 and 1948, however, significant advances were made in formulating the basic geologic history of the Lower Mississippi Alluvial Valley. Dr. Fisk's comprehensive work on the valley, published by the Mississippi River Commission in 1944, and subsequent reports amply demonstrated the value of applying geologic principles to river engineering problems and laid the foundation for many of the geologic studies which were to come.

Postwar Years

26. In late 1946, Mr. Jervis left the WES and his duties were taken over by S. J. Johnson. In the early postwar years there was a fairly definite division of effort between Civil Works projects and projects related to military operations. Many of the Civil Works projects were naturally related to problems of the Mississippi River Commission and the Lower Mississippi Valley Division (LMVD) and were associated with flood-control structures along the Mississippi River and a series of major earth dams constructed on tributary streams, such as Sardis, Arkabutla, Enid, Grenada, Blakely Mountain, and other dams. Improvements in design methods, sampling procedures, field compaction processes, and other problem areas were made. Special note should be made of the development of design and installation techniques for relief wells, and subdrain systems. Filter design criteria developed at WES during this period were an important contribution.

27. When immediate construction of an H bomb plant became essential to the country's welfare in late 1950, the Du Pont Company was requested to construct it and in turn asked the CE to handle all foundation design investigations including exploration, geological, soil mechanics, and foundation engineering studies. Because the project was the largest single facility ever constructed, costing about 1-1/2 billion dollars, Du Pont concluded that available private facilities could not accomplish the desired foundation engineering work in the limited time available, since construction started simultaneously with design. The OCE assigned technical direction and responsibility to the Soils Division, with S. J. Johnson in charge, with instructions to utilize fully all facilities of the CE that might be required.

28. The work was conducted on a crash basis and utilized geologists, soils engineers, drilling crews, geophysical experts, and laboratory testing facilities of the WES. Drilling crews and laboratory facilities from numerous districts of the CE were also used, including the facilities of the South Atlantic Division, which had the basic responsibility for the work, and its Charleston, Savannah, and Mobile Districts. Foundation problems were considerably more difficult than had been envisioned and required elaborate studies to evaluate the engineering significance of "sinks" in the area. These were investigated in detail for the first time on this project and their cause found to be subsurface solution of calcareous materials. This required extensive grouting beneath major structures of the plant, but it was possible to construct and use large sensitive structures without incident.

29. Dr. M. Juul Hvorslev was brought to WES from Harvard University in 1946 to complete his classic work on subsurface exploration. He has been employed subsequently as a consultant to the Chief, Soils Division. In this capacity, he has provided technical assistance on a wide variety of projects. He is also responsible for the design and construction at WES of various field sampling and exploration devices and the first annular shear apparatus in this country and has made major contributions through research in shear strength and bearing capacity theory.

30. Generally, the areas in the floodplain of the Mississippi River consist of a stratum of cohesive fine-grain material underlain by a massive sand formation. The characteristics of these sand formations have always been of importance in connection with the stability of riverbanks and the migration tendencies of the river. Knowledge of the in-place density of these sand strata was essential. Under the direction of T. B. Goode, a method of obtaining essentially undisturbed samples of a clean sand beneath the water table was developed. J. K. Elliott, A. O. Brown, and Decatur P. Jones received official recognition and a cash award for their contributions for the development of this important technique.

31. Underseepage investigations along the Mississippi River were carried on throughout the 1940's. C. I. Mansur was associated with the project in 1941 and became project engineer a few years later. In 1947, a committee on underseepage for the MRC was appointed under the chairmanship of W. J. Turnbull. This study was of material assistance in the WES design of underseepage facilities for the St. Louis District in the mid-1950's. The control measures included installation of over 2000 pressure relief wells. As part of the underseepage investigations, procedures for field permeability determinations and installation of pressure relief wells were developed and refined.

32. The observation of the behavior of completed structures received significant attention and installation of settlement plates, earth pressure cells, and hydrostatic pressure cells was made at a number of dams both in the embankment proper and on outlet facilities and retaining walls.

33. Most of the military work performed during this period was related to airfields. An extraordinary effort was required to keep design procedures for the entire flexible pavement structure current with the rapidly and ever-increasing size and weight of military aircraft. Major efforts were devoted to research in paving mix designs and in compaction procedures for base courses, subbases, and subgrades. In 1946, W. H. Larson joined the bituminous laboratory staff. The accumulation of moisture under pavements and the consequent potential deterioration of base courses were of serious concern. A comprehensive field investigation of this phenomena was conducted under the direction of J. F. Redus and the findings added greatly to our store of knowledge.

34. The comprehensive program on compaction equipment and procedures was probably the most complete such study ever made. The importance of the foot size and roller weight of sheepsfoot rollers was determined and the usefulness and importance of compaction with rubber-tired rollers was clearly established. This collective effort represents a landmark contribution to the knowledge of soil compaction. The behavior of vibratory rollers was also studied in a serious manner and the ground motion and dissipation of the induced forces were studied with their effect on compaction. W. R. Perret contributed significantly to the design of suitable instruments and in the analyses of data used in this type work.

35. A fundamental parameter governing the behavior of an airfield flexible pavement is the distribution of stress under a loaded wheel. One of the most comprehensive series of full-scale tests ever reported was made. Uniform loads of varying magnitude were applied over various diameter circular areas and the resulting pressures and deformations at depth were measured. The results of this study were a major contribution to our knowledge of stress distribution under loaded areas, and caused a general modification to accepted concepts of soil stress patterns.

36. In 1948, a Geology Branch was established in the Soils Division with R. J. LeBlanc in charge. Shortly thereafter he was succeeded by Dr. J. R. Schultz. The Geology Branch has since remained an important element of the Soils Division. Geological investigations in 1948 and in the immediately ensuing years consisted principally of specific site studies for dams, levees, and similar engineering works being built in the Lower Mississippi Valley.

37. An important facet of development in the Soils Division was the broadening use of consulting boards during this period. From this time forward to the present, the use of boards and individual consultants has been found to be highly profitable in the conduct of the Soils Division work. Further details in connection with consultants are shown in the section entitled "Consultants and Consulting Boards."

Period from the Korean War to 1957

38. The WES sponsored an Army reserve unit, the 434th Engineer Construction

Battalion, which was called to active duty in August 1950 for duty in Korea. Personnel belonging to this unit made up a cross section of WES personnel and a number of Soils Division personnel were involved. The effect of the Korean War was of course not nearly as serious as World War II.

39. In 1950, Keith Boyd transferred from the WES to the Bureau of Public Roads and was replaced by C. R. Foster as chief of the Flexible Pavement Branch. Mr. Foster directed the work of this Branch through a period of rapid changes and development in pavement design.

40. The basic organization of the Soils Division remained fairly constant during the next several years except for a steady increase in the number of personnel and size of the work program in each of the elements of the Division. Shortly after the termination of the Korean War, S. J. Johnson left the WES for employment with a private consulting firm and was replaced by W. G. Shockley as chief of the Embankment and Foundation Branch. C. I. Mansur served as chief of the Design and Analytical Section from 1946-1954 and became assistant chief of the Embankment and Foundation Branch in the latter part of 1954. Mr. Mansur left the WES in 1957 to serve as chief of the Geology and Materials Branch at the MRC. R. I. Kaufman, who came to the Soils Division in 1948 as a project engineer, succeeded Mr. Mansur as chief of the Design and Analytical Section in the latter part of 1954, and left the latter part of 1957 to become chief of the Geology and Materials Branch at the MRC.

41. It is indicated in the main body of this History that the work of the WES gradually reached into broader fields and in 1949 the administration of the WES was changed from the MRC to the OCE. This expansion continued as more and more work for other agencies continued.

42. The work for the Air Force was a major element in the Flexible Pavement Branch. In 1951, a program was initiated to evaluate the condition and load-carrying capability of over 100 airfields in overseas locations. This effort was fairly continuous through 1956 and entailed an enormous amount of travel in Greenland, Europe, the Middle East, and North Africa. Of considerable importance in this work were the efforts of the Geology Branch personnel who accompanied each evaluation team. As had been the case in the Mississippi Alluvial Valley since the early 1940's, extensive use was made of air photo interpretive techniques. Use of and refinements to these techniques were developed for the identification of landforms, engineering soils, and construction material sites for the wide variety of climatic, topographic, and physiographic situations represented by the many overseas locations.

43. The following noteworthy development occurred in the laboratory section of the Flexible Pavement Branch during the period 1955 to 1957. Under the direction of J. L. McRae, a so-called gyratory compactor was developed in a basic study on bituminous concrete mixes. The idea of a hand gyratory compactor was obtained from

an engineer of the Texas Highway Department who had developed a hand-operated device. The machine was mechanized and testing procedures were developed to the extent that the equipment is now used as an alternate to the Marshall method of test and design of bituminous mixtures, particularly for the heavy-duty pavements. This equipment and test procedures represent a real breakthrough in producing laboratory test specimens with physical characteristics more closely approximating those obtained in field compaction. The same may be true for soils; however, research studies have not yet been carried far enough to determine this.

44. In 1955, Dr. C. R. Kolb replaced Dr. J. R. Schultz, who had accepted a position elsewhere, as chief of the Geology Branch and the Branch was involved in what is now a major activity of the Mobility and Environmental Division. This activity had its start in the Soils Division with the visit of Dr. Paul Siple and R. R. Philippe, OCE, who assisted in laying the groundwork for a project then known as Military Evaluation of Geographic Areas. This program dealt with efforts to define quantitatively the effects of pertinent aspects of terrain and climate on military operations. A. A. Maxwell was the first project engineer on this program, assisted by W. L. McInnis, J. R. Compton, and others. The major share of effort was expended by the Geology Branch where preliminary studies on quantitative terrain parameters and desert terrain analogs by Drs. Kolb and J. R. Van Lopik were later supplemented by the work of Warren Grabau. The trafficability and area evaluation work was carried on in the Soils Division as the Army Mobility Research Center from 1958 to 1962 with S. J. Knight as head. In 1963, it was converted to the Mobility and Environmental Division headed by W. G. Shockley.

45. In 1957, Messrs. Foster and Shockley are shown as assistant chiefs of the Soils Division, with Mr. Shockley having a dual assignment as chief of the Embankment and Foundation Branch, and A. A. Maxwell as chief of the Flexible Pavement Branch.

The Past Decade

46. The rate of diversification of work in the Soils Division over the last decade has been very rapid. For this reason, the story of the Soils Division cannot be continued in chronological order. Instead, the missions and responsibilities of the various elements of the Division, as currently constituted, will be reviewed in an effort to present a reasonably complete picture of the growth during these years.

47. The increase in the scope of activities of the Soils Division was not really a planned occurrence nor did it begin with any particular event or change of policy. As new problems arose, new facilities and techniques were established to provide answers to certain problems; and as facilities, personnel, and know-how increased, the clients of the Division also increased. In fact, the point has been approached over the last few years where work assignments from the CE and other

governmental agencies are making it extremely difficult to continue to increase capabilities rapidly enough to keep abreast with work assignments.

48. As indicated earlier, W. J. Turnbull has continued as chief of the Soils Division to the present time, with A. A. Maxwell becoming assistant chief in 1964. In 1965, S. J. Johnson returned to the Soils Division as special assistant to Mr. Turnbull.

Embankment and Foundation Branch

49. The Embankment and Foundation Branch, under the direction of J. R. Compton, is the oldest branch in the Soils Division. Almost all of the work assigned to this Branch is related to responsibilities of the CE with respect to Civil Works activities. This Branch operates a large, well-equipped soils testing laboratory which not only serves the need of all in-house projects at the WES but is also the Division Laboratory for the Lower Mississippi Valley Division. Acting as the Division Laboratory, it serves the needs of the St. Louis, Memphis, Vicksburg, and New Orleans Districts. The fulfillment of these responsibilities required a significant expansion in facilities. Also, positive steps were taken to incorporate automatic controls on all test equipment where such was feasible to permit the conduct of a larger number of tests with a minimum increase in personnel. Advantage was also taken of automatic data recording and processing equipment and techniques.

50. A Soils Research Laboratory has been established. New and improved soil testing equipment and testing techniques will be examined in this laboratory and evaluated for their worth in characterizing soil properties. Examples of such equipment are the annular shear and plane-strain shear tests. In addition to research activities, the more unusual and complex testing in connection with current projects will be examined in this laboratory.

51. The Civil Works Directorate of the OCE supports a continuing program of projects entitled "Engineering Studies" which provides a continual updating of many facilities in the soil mechanics field that have to do with Civil Works activities. For example, standard test procedures were established for use by all division laboratories, improved methods of foundation and slope designs are examined, and design manuals are revised or rewritten to take advantage of newly acquired knowledge.

52. For a number of years personnel of this Branch have been supporting the Nuclear Cratering Group (NCG), a CE agency whose interest lies in the peaceful use of atomic energy in such fields, for example, as nuclear excavations. The prediction of engineering properties of nuclear craters and in particular the stability of cratered slopes poses many challenging problems. Because excavation by nuclear means will probably be more economical in rock than in other media, an interest in rock mechanics naturally followed. The application of finite element techniques for assessing the stress distribution in rock slopes was found to be of considerable

value. Capabilities in the field of rock mechanics are rapidly increasing with a full section devoted to the studies.

53. A group of design engineers within the Branch headed by W. C. Sherman, Jr., frequently render assistance to the LMVD on foundation and other problems associated with locks, dams, levees, etc. This assistance has included the conduct and analysis of major pile load test programs such as the Morganza and Old River Control Structures and instrumentation of U-frame lock structures such as Port Allen and Old River Locks, the data from which have been of material assistance to other offices designing similar structures.

54. The Inspection and Exploration Section, formerly under T. B. Goode (retired) and now under A. L. Mathews, has broad capabilities in subsurface investigations and field testing in rock and soil media, has developed many special sampling devices, and has utilized the most advanced equipment available, such as the borehole TV camera. Many thousands of feet of borings have been made at the Nevada Test Station in support of the NCG activities and the Atomic Energy Commission. Support has been given to the Air Force in connection with their HEST series of tests and to other agencies as required.

Flexible Pavement Branch

55. The Flexible Pavement Branch, under the direction of R. G. Ahlvin, is the second oldest branch in the Soils Division and was established in the early days of World War II to meet an urgent need for the development of airfield pavement design methods. This Branch still has the responsibility of continually updating design manuals and guide specifications relating to all phases of flexible pavement construction for both the Air Force and the Army. A design capability is maintained extending to the heaviest loadings, and covering not only conventional flexible pavements, but also landing mat surfaced and unsurfaced areas as well.

56. Two continuing investigational programs are in progress: one program financed by the Military Construction Directorate of OCE and the other program financed by the Air Force, and both are directed toward problems related to airfield design and construction. These programs supplement each other and are usually reviewed at the same time by a group of consultants who provide valuable guidance to approaches to the solution of problems and elimination of duplication of effort.

57. In recent years there has been little or no requirement for the construction of new airfield facilities; hence problems are occurring more frequently in the field of maintenance rather than design or construction techniques and investigational programs have been directed accordingly. Assistance is provided frequently to both the Air Force and the Army in the evaluation of existing airfield pavements in order to provide information necessary to plan major maintenance or reconstruction programs. A. H. Joseph and P. J. Vedros, who were key personnel in

the evaluation of over 100 airfields overseas, are still responsible for this phase of activity. L. M. Womack drew many assignments that involved troubleshooting and assistance to the Air Force on pavement problems. He transferred to the Air Force Weapons Laboratory (AFWL) in 1967.

58. The ever-increasing size and weight of both military and civilian aircraft have posed a continuing problem in regard to the design of the pavement on which they operate. It is not difficult to conjecture that an aircraft could be built which could grossly overload all existing landing facilities and thus would have nowhere to operate from. The logical procedure is to determine what landing gear configuration is required to permit a plane of a given weight to operate on a given surface. This concept is general in that it is not restricted to high-type performance found at major airports but also covers the operation of aircraft on unsurfaced ground areas as are found in the theater of operations (TO) where military aircraft are required to operate from the most primitive of flight strips. It was determined that the basic concepts applicable to flexible pavements could be extended to the operation of aircraft on unsurfaced or expedient (landing mat, membrane) surfaced areas and furnish valuable information for the design of appropriate landing gear. R. G. Ahlvin, D. N. Brown, D. M. Ladd, and H. H. Ulery, Jr., were instrumental in developing these techniques which have come to be termed the "flotation requirements" of aircraft. Specific use of this approach was made in the design of a landing gear for the gigantic C5A military aircraft now under construction. A mock-up of the proposed gear consisting of 12 wheels on each main gear was constructed and full-scale tests made on both unsurfaced and paved areas.

59. The validation of many specifications for pavements, base courses, landing mats, etc., requires actual traffic testing under full-scale wheel loads. This need has been met by the establishment of a Field Test Section within the Flexible Pavement Branch. The design and construction of such test sections require unusual know-how. To design a pavement or base course that will ensure failure with application of a reasonable amount of traffic is much more difficult than to prepare a design which will ensure that no failure occurs and failures are necessary in this type work in order to establish performance limits. C. D. Burns, with the able assistance of J. E. Watkins and Miller Mathews, has taken a major part in the development of test section designs. The Field Test Section, in addition to performing all field testing required of the Flexible Pavement Branch, also designs and performs field tests on landing mats and other surfaces in support of the Expedient Surfaces Branch discussed subsequently.

Geology Branch

60. The Geology Branch under the direction of Dr. C. R. Kolb has never been large numerically; however, the Branch is staffed with individuals well qualified in a wide variety of geologic disciplines. With four Ph. D.'s, the Branch has a

higher percentage of advanced degrees than any other branch at WES.

61. Initially, the work of the Branch was confined to problems associated with construction in the Alluvial Valley of the Mississippi River. The work of Dr. Fisk in the 1940's in the alluvial valley has been supplemented since that time by detailed mapping of the alluvial environments of deposition and their associated engineering soils types. The documentation of the meanderings of the Mississippi River in the recent geologic past is perhaps the best of any such stream in the world and, as such, of considerable value in WES potamology and revetment studies.

62. Of particular importance has been work done in the late 1950's and early 1960's by Drs. Kolb, Van Lopik, and R. T. Saucier on the deltaic plain of the Mississippi. A series of comprehensive reports on the deltaic environments of deposition have become standard references for investigations of deltas and the influence of deltaic soils on engineering projects. A current by-product of these studies is their value in a project designed to locate construction material and building sites in the Mekong Delta.

63. The geology Branch has cooperated with LMVD on numerous projects involving subsurface conditions encountered in connection with the siting and construction of locks, dams, levees, pumping plants, and other engineering structures. Among the more comprehensive of these projects which deserve special mention are the investigation of Mississippi River diversion by the Atchafalaya River, the distribution of engineering soils bordering the Mississippi River from Donaldsonville, La., to the Gulf, groundwater in the alluvium of the Lower Mississippi Valley, and the recently completed geological investigation of the Texas Water Project area.

64. In 1964, a sedimentation laboratory was established in the Branch under the direction of Dr. Ellis Krinitzsky with the objective of studying the effects of depositional environments and postdepositional changes in sediments on their strength properties. His recent work in the utilization of X-radiography techniques offers a new and valuable insight into the structural fabric of soils and rock and a means to significantly refine evaluation of their engineering properties.

65. A sizable portion of the Branch effort is concerned with quantitative terrain studies being directed by John Shamburger as a support to the Mobility and Environmental Division. An equally sizable Branch effort is being expended in the field of rock mechanics under the direction of W. B. Steinriede, Jr. Support is provided to the NCG in preshot and postshot studies of the effect of nuclear cratering on rock fracturing and the stability of rock slopes. The Branch possesses two borehole cameras, which are widely used in such studies, and significant advances have been made in statistically relating borehole camera data to joint phenomenology. Contributions have been made in this area by Dr. Richard Lutton in his work on cratered slopes, slopes in mining excavations, naturally occurring rock slopes, and blasting phenomena.

Soil Dynamics Branch

66. The Soil Dynamics Branch, under the direction of R. W. Cunny, was established in 1963. This Branch was drawn from an element in the Flexible Pavement Branch which was involved in the development of procedures for predicting resonant frequency and displacement response of radar tower foundations, and an element from the Embankment and Foundation Branch which was engaged in the study of the response of soil and soil structure system to impulse loads like those produced by nuclear airblast. In 1965, a third element was added which now has responsibility for fundamental ground motion studies and study of earth- and rock-fill dams under earthquake loading. Lyman Heller as section chief is in general charge of this effort.

67. Historically, soil tests were of a static nature and most soil problems were related to the action of more or less static forces. This changed with the advent of the space age and atomic energy and knowledge of the performance of soils under dynamic loads became essential. Among the first problems was the stability of foundations of structures such as radar towers and instrument calibration facilities where an absolute minimum amount of motion or deflection could be tolerated. Permissible motion in many cases was so small as to be well within the limits of the elastic behavior of the foundation materials. The initial criteria for the NIKE ZEUS radar towers contained limitations on deflection, resonant frequency, and damping. Such criteria require information on the characteristics of the force input and the elastic moduli of the foundation. Any solution must, of course, consider the combined behavior of the tower and the foundation.

68. Comprehensive test programs were initiated to establish the behavior of soils under oscillating forces and the relation of this behavior to the elastic moduli of the foundation soils. Load deflection characteristics could be obtained directly by simply subjecting slab foundations to oscillating forces; however, the determination of elastic constants by independent means was a difficult problem. Techniques developed by the Shell Oil Company for the nondestructive testing of flexible pavements were modified and adopted for use on soils as well as pavements. These techniques permitted determination of elastic properties by two independent methods; one method involving load deflection characteristics and the other method involving a measurement of the velocity of wave propagation in the foundation materials. Based on the results from the in-house test program and the work of others, a design manual was prepared on slab foundations subjected to dynamic loads. Opportunities arose whereby Soils Division personnel had an opportunity to perform a field investigation at a construction site to provide input to the foundation design, and then to instrument and monitor the behavior of the tower after construction in order to check the design procedures. The field investigative techniques developed for determination of in situ foundation properties are now being used at all potential installation sites for the new air defense Sentinel System.

A. A. Maxwell, Z. B. Fry, Jr., and R. F. Ballard, Jr., have contributed significantly to this work.

69. Once a capability had been established for work in this area, other applications rapidly occurred. Measurements were made of the launch systems at Cape Canaveral to determine the behavior of these stands during the firing of an operation vehicle and also the propagation of the ground motion to outlying areas was observed. Methods were developed to estimate ground motion to be expected from future firings of much larger vehicles. Motion of the gigantic test stands planned for the National Aeronautics and Space Administration (NASA) test facility in Mississippi was of concern and the Soils Division participated in a complex test program in which test pilings were subjected to a combination of static and oscillating forces. Later, numerous piles to be used for the structure foundation were instrumented with strain gages and after completion of the structure, the motion of the structure has been monitored during test firing and the behavior of the pile foundation under these dynamic loads observed.

70. An entirely different type of ground motion occurs as a result of explosions of nuclear devices. The characteristics and effect of these shock waves in impulse loads in the ground were of obvious interest. The Nuclear Weapons Effects Division (NWED) at WES has for a number of years rendered support to the Defense Atomic Support Agency (DASA), the Air Force, and the Atomic Energy Commission (AEC) in dealing with shock phenomena. The Soil Dynamics Branch of the Soils Division has in turn supported NWED in their efforts for determination of the behavior of soil and soil structure systems under impulse loads of very large magnitude. Through contract and in-house effort, laboratory equipment has been designed and constructed for the testing of undisturbed and remolded soil specimens subjected to impulse loads. The results of such tests provide what is perhaps now the most reliable measure of the behavior of particular soils under specified loading conditions and are used in computer programs established for the prediction of shock effects and ground motion. J. G. Jackson and L. Schindler have made major contributions in this problem area. In addition to studies relating to propagation of impulse loads in soil media, major work has been done on the effect of large-magnitude single-pulse loads on footings founded both on and in cohesionless and cohesive soils and an excellent understanding has been obtained of this phenomena. P. F. Hadala has made significant contributions to this work.

Expedient Surfaces Branch

71. As mentioned earlier, the Soils Division was involved with testing of landing mat and membranes in the early days of World War II on a relatively small scale. The products available at that time were designed for expedient-type airfield surfacing and for beach operations. At a later date, the responsibility for expedient surfacing was formalized and the development of suitable items was assigned to the Mobility Equipment Research and Development Center (MERDC),

Fort Belvoir, Virginia. It soon became evident that the behavior of the surfacing and the soil was so interdependent that they could not be studied separately. The responsibility for the development of expedient surfacing was then transferred to WES in about 1958. Only a few of the engineers associated with this project at MERDC actually transferred to WES with the transfer of the mission; presently the only one remaining is G. R. Kozan. Among these was Bruce Spangler who was placed in charge of this work at WES. Mr. Spangler remained at WES for only one year and returned to MERDC; however, during this period he was successful in establishing an efficient organization for this rather unusual type of work and in making available his knowledge on this subject. W. L. McInnis succeeded Mr. Spangler as chief of what is now the Expedient Surfaces Branch. The mission of this Branch is primarily to develop landing mats, waterproof and dustproof membrane surfacing, and soil stabilization additives and techniques for use by troops in the TO.

72. Initially, the design of a new product would be completed in-house and sufficient quantities procured for engineer tests at WES, results reported, and when superior items were disclosed, larger quantities would be procured by other agencies for full-scale service tests by troop units. This work was funded by the CE out of R&D funds. In 1962, with the establishment of the Army Materiel Command (AMC), the responsibility for the development of items for troop use changed from the CE to the AMC. The WES has continued to conduct this project for AMC as was formerly done for the CE. The assistance of industry is obtained by means of developmental contracts. Also, some manufacturers develop products with their own resources and submit them to WES for tests and evaluation.

73. Currently, one membrane, developed under the supervision of S. G. Tucker, has been standardized and is an item of Army supply. Landing mats have encountered the same problem as airfield pavements in that what was good yesterday is not adequate today because of increasing aircraft weight. Mat development was under the direction of Robert Turner, who after retirement has been succeeded by H. L. Green. Steel and/or aluminum mats available today are many times better than the last type of mat to be standardized, the M8; however, none of these have been made a standard item because there is almost at all times a better mat that will be available in the foreseeable future. Although none of the mats developed in-house or by industry (other than the M8 mat) have been made Army standards, their performance is so superior to older products that vast quantities have been purchased on a special basis for use in Vietnam.

Vietnam-Related Activities

74. Activities in Vietnam have raised many problems in the field of military engineering and WES has been called on numerous times for work on some crash program to help solve an immediate requirement in the TO. Many of these problems are

directly related to the projects assigned to the Expedient Surfaces Branch and the Flexible Pavement Branch and these groups of engineers have worked on a number of these crash programs. One of the first such problems was the control of dust in Vietnam. The development of more efficient dust control measures was a must because of the excessive damage being caused to jet aircraft engines by dust. An immediate in-house program was started and industry and other research organizations were contacted for any contribution they could make to solution of this urgent problem. Their response was all that could be asked for and during the next 12 to 15 months approximately 300 products were tested for their dust control potential. This work was under the direction of G. R. Kozan ably assisted by W. H. Larson, chief of the bituminous laboratory; and through a series of screening tests, small-scale laboratory tests, and full-scale field tests, improved products were identified and better products than had been available were procured and furnished to field troops. This Branch has assisted with a number of other Vietnam-related problems of a classified nature and has on several occasions sent engineers to Vietnam to assist with particular problems involving dust control, soil stabilization, and the use of landing mats and membranes for airfield surfacing.

75. Also assigned to the Expedient Surfaces Branch are research and development projects concerned with control of soil erosion and dust resulting from rocket and missile launchings, downwash impingement from helicopters and V/STOL aerial vehicles, and exhaust blast from jet engine aircraft. It was in support of these studies that the Surface Blast Effects facility was developed. Under the direction of G. W. Leese, the facility is used for evaluating the soil erosion control potential of materials and control methods by subjecting them to actual exhaust blasts characteristic of rockets and jet engines and the downwash of ducted fans and helicopters.

76. The Flexible Pavement Branch has also made major contributions in solving Vietnam-related problems. W. B. Fenwick has been project engineer on several crash programs concerned with the development of revetments or protection of Army aircraft, troop shelters, and others. He also served on several occasions as civilian technical adviser to engineer troop units in the field, receiving training in field construction techniques and procedures.

Today's Organization

77. The Soils Division, as constituted today, is represented by fig. VI-1. A comparison of this organization chart with the one in the main text for the year 1937, gives some concept of the changes that have taken place over a period of more than 30 years. The budgeted in-house work of the Soils Division for FY 1968 was almost eight million dollars. It is expected to remain at or slightly below this level for the next several years. Personnel of the Soils Division in FY 1968 was upward of 200.

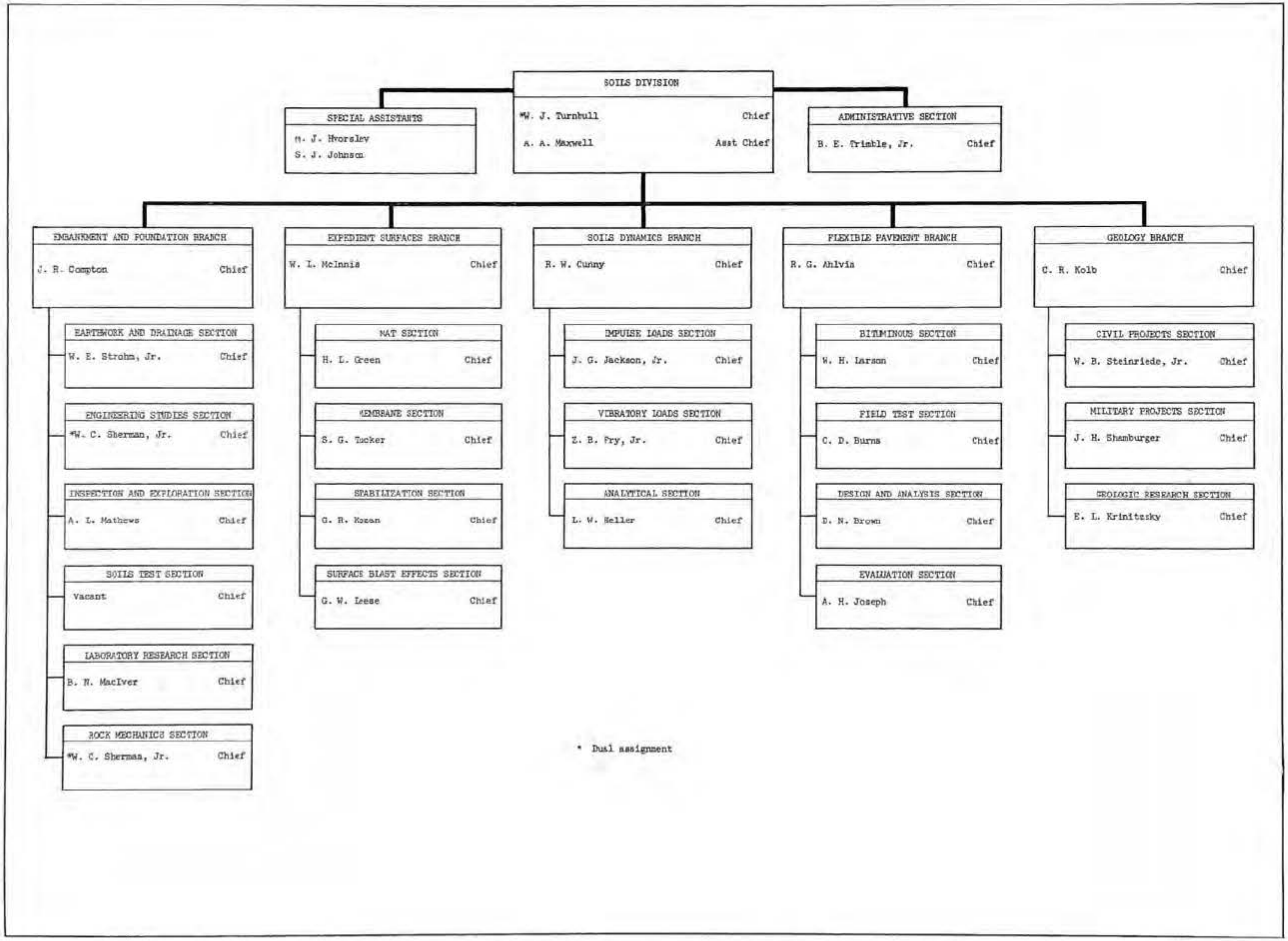

Fig. VI-1. Organization chart, 1 February 1968

Appendix VII

CONCRETE DIVISION

1. The Concrete Division was established in 1946 as the Concrete Research Division and located at the Clinton Suboffice, later designated the Jackson Installation, in temporary quarters made available by the termination at that site of a prisoner-of-war camp. It was believed by some, at the time, that this locality would at a future date be the site of the entire Waterways Experiment Station (WES), it having been noted that it had long-term advantages by reason of including more land, having better access to utilities, having a railroad siding, and being near Jackson, Mississippi. It had the immediate advantage of having buildings that could be and were readily converted into temporary housing for civilian employees.

2. The establishment of the Division represented the culmination of efforts by various individuals, especially Mr. Byram W. Steele of the Engineering Division, Directorate of Civil Works, Office, Chief of Engineers (OCE), to cause the Corps of Engineers to establish a central concrete research and development installation. Mr. Steele, who had been Chief Engineer for Dams at the U. S. Bureau of Reclamation (USBR) in Denver, Colorado, during the Boulder Canyon Project and who supplied the groundwork for the USBR Concrete Manual, became associated with the OCE in 1937. In a very real sense, Mr. Steele may be regarded as the "father" of the Concrete Division.

3. However, the activities that culminated in 1946 with the establishment of the Concrete Division had their origin in the undertaking by the Corps of its major construction projects in the Mississippi Valley and its study of the Passamaquoddy Tidal Power Project. Mr. Charles E. Wuerpel first became associated with concrete construction by the Corps of Engineers in 1928 in connection with the design and construction of the Bonnet Carré Spillway in the New Orleans District. He was later active in the St. Louis District and sometime later set up a concrete laboratory at Eastport, Maine, for work in connection with the Passamaquoddy Tidal Power Project. In December 1936, with the termination of the concrete research work at Eastport, a concrete laboratory was established at the U. S. Military Academy at West Point under Mr. Wuerpel's direction. To that enterprise he brought Herbert K. Cook, who had been associated with him at Eastport, and Thomas B. Kennedy, who had been associated with him at Alton, Illinois.

Central Concrete Laboratory (North Atlantic Division)

4. In 1938, Messrs. Steele and Wuerpel planned an exhaustive investigation of the role of cement variation on the durability of concrete, which was begun in 1939 by the Central Concrete Laboratory of the North Atlantic Division at West Point. It

was at this moment that the Corps of Engineers may be said to have begun its activities in Corps-wide concrete research. Shortly thereafter, additional studies of air entrainment in concrete and of alkali-aggregate reaction were undertaken. In order to properly pursue these studies, chemists, engineers, and a petrographer were employed. Among them were Mr. Albert D. Weiner, who is at present Chief of Foundations and Materials for the North Atlantic Division; Mr. Morris R. Smith, who retired from a position as Assistant Chief, Concrete Branch, Engineering Division, Civil Works, OCE, a few years ago; BG Howard Eggleston, CE (retired), now Managing Director, National Slag Association; Mr. E. C. Shuman, now Professor of Building Technology, Pennsylvania State University; and Mr. E. P. Rexford (deceased), the Corps of Engineers first petrographer; as well as Herbert K. Cook, Thomas B. Kennedy, and Bryant Mather. The program permitted and required a continuation and expansion of the outdoor exposure test facilities that had been prepared at Treat Island, Cobscook Bay, Maine, for the 'Quoddy Project concrete research and the construction of additional facilities at Salt Run, St. Augustine, Florida, both of which are still in use by the Concrete Division.

5. Shortly after the attack on Pearl Harbor, it became desirable to move the Central Concrete Laboratory off the grounds of the U. S. Military Academy. In March 1942, it was reestablished in Mt. Vernon, New York, where it operated until July 1946. During World War II, by arrangement with the National Bureau of Standards, it carried out sampling, inspection, and testing of all portland cement manufactured in New York and New England for use in projects of the U. S. Government, both in the United States and overseas. It also conducted, in cooperation with the Ohio River Division Laboratory, the initial research and development work on membrane-forming compounds for curing concrete, especially military airfield pavements. As World War II drew to a close, it began studies of aggregates and concrete for postwar civil works construction, especially for flood control. At the time the move from Mt. Vernon to Mississippi was made, tests were in progress in connection with aggregate and concrete studies for the Whitney Dam, Texas, and other projects.

Beginnings

6. The arrangements at the Clinton Suboffice for receipt and accommodation of staff and equipment were made by Thomas B. Kennedy; the final arrangements to evacuate the facilities at Mt. Vernon were made by Bryant Mather; the day-to-day operation of the Concrete Research Division was supervised by Herbert K. Cook. All members of the staff of the Central Concrete Laboratory were offered the opportunity to transfer to WES, but only a rather small number did. In addition to Messrs. Wuerpel, Cook, Kennedy, and Mather, others who transferred were Rembert L. Curry, Rose Harrell, and Katharine Mather, who are still members of the staff, and Frank Cuddy, Louis Moyd,

Rhoda Klein, Ambrose Storch, and Warrington G. Mitchell, who served for varying lengths of time after the transfer but then moved on.

Organizational Evolution

7. The first published organization chart (1 July 1946), fig. VII-1, shows 3 branches and 11 sections--more than have existed at any time since then.

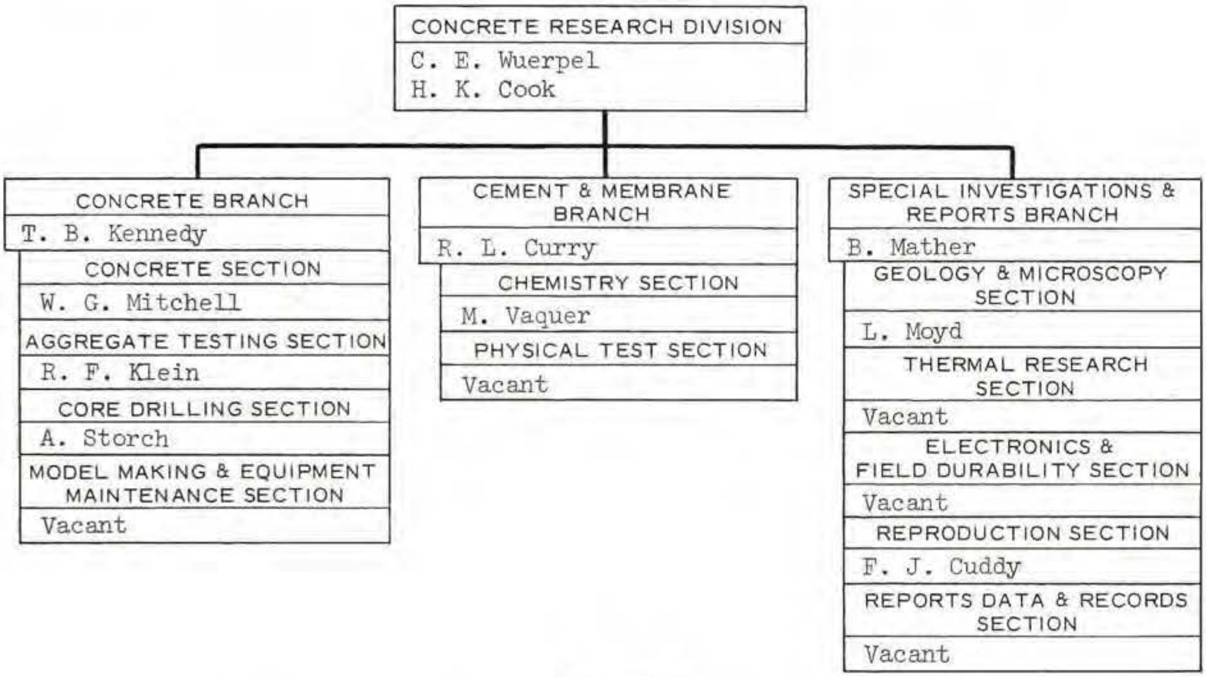

Fig. VII-1

8. By January 1947, there had been a reorganization that eliminated the Cement and Membrane Branch, changed the name of the Concrete Branch to Physical Test Branch, and reduced the number of sections from 11 to 5. This form of organization (shown below) continued, with relatively minor changes to the present time.

CONCRETE RESEARCH DIVISION

Office of Division Chief: Charles E. Wuerpel, Herbert K. Cook, Rose M. Cifardi, Dorothy L. Madole

Physical Test Branch: Thomas B. Kennedy, Annette C. Harris

Mixture Design Section: Stanley M. Hart, William O. Tynes, Frank H. Cooper, S. D. Ray, James Patton, John Cage

Aggregate Testing Section: Rembert L. Curry, Rhoda F. Klein, Claude T. Buel

Special Investigations Branch: Bryant Mather, Olivette C. Phillips

Petrography Section: Louis Moyd, Katharine Mather

Thermal Research and Chemistry Section: Miguel Vacquer, Edwin J. Callan, Luther K. Farrior

Field Durability Section: Montford H. Peabody, Douglas Small

9. By July 1947, Mr. Wuerpel had taken extended leave of absence from the Corps of Engineers to begin an association with the Inter-American Construction Company, a division of the World-Wide Development Corporation, that undertook activities for the government of Argentina. During his absence, Mr. Cook was Acting Chief. Upon Mr. Wuerpel's return to the United States, he was associated briefly with the OCE, and later with the Marquette Cement Manufacturing Company, from which he retired as Vice-President in 1966. He now lives in Portugal. With Mr. Cook's assumption of duties as Division Chief, the title of Assistant Chief was dropped, and a new administrative section, first designated Office Engineer Section, was organized. In July 1947, the Office Engineer was E. O. Schultz; he was succeeded by William S. Gardner, Jr. (now with USAID in Tegucigalpa, Honduras, CA), then by John H. Barnett. In 1952, the section name was changed to Administrative Section, and it was headed successively by James A. Harris, James E. Todd, and since Mr. Todd's retirement in 1960, by Oscar F. Wilks, Jr.

10. The Physical Test Branch remained under the direction of Thomas B. Kennedy from the time of its establishment until Mr. Kennedy became Division Chief in 1954, at which time Mr. James M. Polatty assumed duties as its Chief. The name changed briefly back to Concrete Branch and now is Engineering Mechanics Branch.

11. The Special Investigations Branch remained under the direction of Bryant Mather from the time of its establishment until Mr. Mather became Division Chief in 1966, at which time he was succeeded by Mr. Rennie V. Tye, Jr. The name was changed to Engineering Sciences Branch in 1964.

12. The subdivision of the work of the Division between the branches and into and among sections has varied with the nature and amount of the work and with the availability of staff having managerial ability to function as Section Chiefs. The present arrangement indicated below reflects the current circumstances.

CONCRETE DIVISION

- Office of Division Chief: Bryant Mather, Rose C. Harrell
  - Administrative Section: Oscar F. Wilks, Jr.
  - Engineering Mechanics Branch: James M. Polatty
    - Concrete and Rock Properties Section: William O. Tynes
    - Materials Properties Section: Rembert L. Curry
    - Grouting Section: Ralph A. Bendinelli
    - Engineering Physics Section: Billy R. Sullivan
    - Structures Section: Helmut G. Geymayer
  - Engineering Sciences Branch: Rennie V. Tye, Jr.
    - Petrography and X-Ray Section: Katharine Mather
    - Chemistry and Plastics Section: Leonard Pepper
    - Thermal Research and Durability Section: Ernest E. McCoy, Jr.
    - Cement and Pozzolan Test Section: William G. Miller

The five sections now making up the operating elements of the Engineering Mechanics Branch may be traced, developmentally, from the two that existed in January 1947 as follows: The Aggregate Test Section, headed in 1947 by R. L. Curry, is now the Materials Properties Section, still headed by R. L. Curry. The Mixture Design Section, which in 1947 included W. O. Tynes, is now the Concrete and Rock Properties Section, headed by Mr. Tynes. In 1948, Mr. Cecil H. Willetts transferred from the Tulsa District and became chief of that section; in 1953, the section was divided into two sections, one retaining the title Mixture Design under Walter O. Crawley, the other designated Aggregate Manufacturing and Processing under Edwin A. Spuehler. Mr. Willetts became Assistant Branch Chief under Mr. Kennedy. In 1955, Mr. Spuehler returned to field construction work, and the two sections were merged under W. O. Crawley. In 1955, Mr. Crawley returned to field construction, and the section, redesignated General Investigations, came under the supervision of Mr. Tynes. In 1966, the activities relating to grouting were split off as the Grouting Section, under Mr. Ralph A. Bendinelli. The name was changed to Grouting and Engineering Physics, and in 1967 the Engineering Physics work formed the basis for the organization of the Engineering Physics Section, under Mr. Billy R. Sullivan. In 1963, Dr. Eugene F. Smith, who had been associated with contract work under the direction of the Division conducted at the University of Texas, joined the staff as Assistant to the Division Chief, Mr. Kennedy, with responsibilities in the structures field. In 1965, the Structures Section was organized within the Engineering Mechanics Branch under Dr. Smith. When Dr. Smith transferred in 1966, the work came under the direction of Dr. H. G. Geymayer.

13. In the Special Investigations Branch there has been somewhat less organizational adjustment with time. During much of the period that Mr. Willetts served as Assistant Chief of the Physical Test Branch, Mr. R. V. Tye served as Assistant Chief of the Special Investigations Branch. In 1955, Mr. Tye resigned to become associated with Tecon Construction Company, where he served in various capacities, including Vice-President, in various parts of the world. In 1965, he returned to the staff as Assistant Chief of the Engineering Sciences Branch and became its Chief in 1966. Mrs. Katharine Mather became Chief of the Petrography Section in 1948, following the resignation of Mr. Moyd, who became a consulting mineralogist and who is now Chief Curator of the Canadian National Mineral Collection in Ottawa. Later, this section was designated, for greater accuracy, the Petrography and X-Ray Section. Mr. J. C. Woosley became Chief of the Chemistry Section in 1948 and was followed in 1949 by Mr. Leonard Pepper. Effective 16 February 1968, the Chemistry Section was designated Chemistry and Plastics Section to recognize the growing role of plastics and resins in the program of the Concrete Division. The Thermal Research part of the Thermal Research and Chemistry Section and the Field Durability Section were combined in 1948 as Thermal Research and Field Durability, with Edwin J. Callan as Chief. In 1952, when Mr. Callan joined the Air Force Laboratories at

Wright-Patterson Air Force Base, where he still is, the work came under the direction of Mr. E. E. McCoy, Jr. Later the word "Field" was dropped from the title. The Cement and Pozzolan Test Section was created in 1966 under the direction of Mr. William G. Miller to assume the duties assigned WES by OCE in connection with the termination of activity by the National Bureau of Standards in the field of cement testing.

Military Personnel

14. The Concrete Division was composed exclusively of civilian employees until 1962, when the first of a series of enlisted men was assigned. On the organization chart for 1 January 1963 are shown a Physical Science Assistant (S&E) (908) E-4, Howard Sugiuchi, a physicist; and a Civil Engineering Assistant (S&E) (509) E-3, George Hoff. Mr. Sugiuchi and Mr. Hoff both accepted employment with the Division as civilian professional employees upon completion of their military service. Mr. Sugiuchi, first as an enlisted man and later as a civilian staff member, pioneered the work in the field of dynamic testing of materials that later formed the basis for the establishment of the Engineering Physics Section of the Engineering Mechanics Branch. Mr. Hoff, first as an enlisted man and later as a civilian staff member, pioneered and continues as project leader for the extensive work on shock-mitigating backpacking materials. In the years following the initiation of the assignment of enlisted men to technical staff duties with the Division, a large amount of valuable and useful work has been accomplished by and under the direction of these men. Most have been offered professional appointment as civilian staff members on completion of their military service; most of those offered such appointment have accepted.

15. In 1962, 1LT Delbert E. Day, CE, was assigned as the first military assistant (officer) in the Division. Dr. Day, who had received a Ph. D. from Penn State in ceramics, was a member of the faculty in ceramic engineering at the University of Missouri at Rolla when he was ordered to active duty. During his service with the Division, he was a member of the staff of the Petrography and X-Ray Section. Among the outstanding research studies he conducted was an early application, the first in cement chemistry, of the technique of establishing the coordination number of ions by wavelength of emitted X-rays. This work was reported to the Mississippi Academy of Sciences in April 1963 and to the Highway Research Board in January 1964. A report was published in Nature (London), No. 4907, 16 Nov 63, pp 649-51, and as WES MP 6-604. This work has been referred to subsequently as anticipating Mossbauer spectroscopy.

Facilities

16. The Concrete Division, and its predecessor organizations, have utilized

successively larger and better facilities for the accomplishment of the work. Landmarks in this development have been the move from temporary quarters over the fruit and vegetable market at the U. S. Military Academy to a floor in the then newly constructed Ordnance Maintenance Building in 1940; to quarters leased from the Westchester Lighting Company in Mt. Vernon, N. Y., in 1942; to temporary quarters at the Clinton Suboffice of the WES in 1946; and to permanent quarters there in stages thereafter. The major, and perhaps final move, is scheduled for 1969 to the building being constructed at a cost of more than $2,000,000 at the Vicksburg Installation of the WES. This building, which will contain about 90,000 sq ft, more than twice that available in the present facilities, may be the largest concrete research laboratory in existence.

Work Program

17. The summary of WES work, covering the period July-September 1946, was the first to contain a section on "Concrete." It listed three studies: Air-Entrainment Research (later ES 601), Investigation of Vacuum-Processed Concrete (later ES 605), and Investigation of Aggregate Reactivity of Concrete, Santee-Cooper Project, conducted for the South Carolina Public Service Authority. In 1948, the Civil Works Investigations-Engineering Studies (CWI-ES) Program, sponsored by OCE, was initiated as the principal sponsor of the investigational work relating to concrete conducted by the WES. The activities in this field that have been conducted at the WES since 1946 have continued without interruption since 1936 when the first of them (now ES 604) was initiated under the supervision of the concrete laboratory of the Eastport (Maine) District. Nearly 40 separate CWI-ES items have been used since 1948 to cover these studies. These items have included work of many sorts. Some items have covered a single project, others more than 50.

18. The purpose of all activities of the WES in connection with CWI-ES, Concrete, is to develop and disseminate information that will permit improvements in the economy and quality of the concrete construction activities of the Corps of Engineers.

19. This purpose is served by limiting these activities to those which, in the judgment of OCE, will directly and specifically contribute to this objective. Reports of work accomplished are distributed to all field offices and key personnel concerned, accompanied when appropriate by a directive from OCE, indicating the immediate steps to be taken to apply the results of the work to field conditions. Since 1948, the Concrete Division has conducted the investigational work in 36 CWI-ES items, 28 of which have specifically concerned concrete as a material, 7 have dealt with structural matters, and 1 has concerned grouting of foundations. In the justification sheets prepared in February 1968 for FY 1970, work was proposed in 22 of these items. Work in the other 14 has been completed. The 22 current fields

include the following areas of research and study: admixtures for concrete; mass concrete; concrete aggregates; alkali-aggregate reactions; field exposure; test methods; cementitious materials; construction plant and equipment; construction practices; concrete mixture proportioning; placeability of concrete; forming, finishing, and curing concrete; concrete materials other than aggregates and cements; structural behavior; time-dependent volume changes; epoxy resins and other adhesives; shotcrete; waterstops; reinforced concrete beams; prestressed concrete; grouting; and models of mass concrete structures.

20. The Chief of Engineers, MG S. D. Sturgis, Jr., CE, commented on concrete research in 1954, as follows:

> It was not until 1939 that we set up our first major concrete investigation program aimed at attacking fundamental problems common to many projects. The Waterways Experiment Station was expanded by the inclusion of a concrete laboratory in 1946. This laboratory, among other facilities, maintains two concrete exposure stations, one at Treat Island, Me., and the other at St. Augustine, Fla., where specimens are subjected to alternate wetting and drying, and freezing and thawing. On the basis of these open-air tests, we have been able to set up controlled laboratory tests. The Vicksburg station also has a modern concrete batching and mixing plant used for testing mixes and placement processes.
>
> We have been studying air entrainment since 1939, with the result that our testing and specification work is now standardized and the public has been saved millions of dollars. We have also done a great deal of rather specialized work on aggregates with the view of establishing criteria which will help us make the most economical use of locally available materials in any area of the world. Among other things, we have tested samples from more than 2,000 sources representing every section of the United States, so that we may specify our aggregate sources with full knowledge of both the technical and economic implications. Our studies on the mechanical properties of aggregates have enabled us to reduce our average cement factors for interior mass concrete from the 3- to 4-bag per cu yd factor which prevailed before 1948 to something like 2-1/2-bags per cu yd today--and again, the public has been saved millions of dollars.
>
> Our studies are not confined to materials; we also seek improvements in procedures and plant. We are testing new methods of evaluating structures and locating flaws, and a wide range of equipment, including forms, linings, form anchors, vibrators, buckets, and electronic indicating and recording devices for batching plants.
>
> As a result of these studies, we have been able to give the American people better structures at lower cost, which is always our ultimate objective in construction. We can measure the value of our studies in dollars. During the years 1946 through 1948, the average unit bid price for concrete for our gravity dams was approximately \$11.75 per cu yd. Today, despite increased costs of labor, higher prices of materials, and bigger and more complex structures with more rigid specifications--factors which might well have doubled our concrete costs--we find instead that the unit bid price for gravity dams has decreased to about \$8.25 per cu yd, a decrease of 30 percent.

Method of Operation

21. Except for that portion of its work that involves the performance of

standard acceptance tests on samples representing materials such as cement, fly ash, air-entraining admixtures, membrane-forming curing compounds for use in construction, each research or investigational project conducted at the Concrete Division is carried out in accordance with a plan set forth in a Memorandum for All Concerned, copies of which are furnished to the supervisors concerned. One of its latest memoranda (No. 1657) was issued to cover the development of a grout mixture that will develop a compressive strength of 200-500 psi in four hours to use in maintaining landing-mat-surfaced airfields. Memorandum No. 5 (the earliest that has been located), issued in 1946, covered tests to be performed on eight samples of aggregate from six sources in South Dakota, North Dakota, Iowa, and Minnesota for the Omaha District in connection with proposed construction of main-stem dams in the Missouri River Basin.

Appendix VIII

NUCLEAR WEAPONS EFFECTS DIVISION

Introduction

1. The history of explosions effects research at the WES is of significance because of the many contributions that have been made toward a better understanding of explosion-produced phenomena. This is particularly true concerning nuclear weapons effects research. As our experiences became broader and capabilities grew, changes in methods, organization, emphasis, and objectives occurred. Such evolutionary processes are evident in the history of the Nuclear Weapons Effects Division (NWED).

2. The history of NWED is presented herein under rather broad subjects rather than as a chronological record of year-to-year activities. The sources of information for compiling the history were numerous; e.g., time and attendance records, laboratory notebooks and/or diaries, funding documents, technical reports, minutes of conferences, memoranda for record, trip reports, etc. The history was prepared by Messrs. J. N. Strange, L. F. Ingram, W. J. Flathau, and L. Miller, and Mesdames M. O. Kleinman and I. H. Rice. Mr. G. L. Arbuthnot, Jr., served as editor.

Origin of the Nuclear Weapons Effects Division

3. On 12 January 1951, in the absence of COL H. J. Skidmore, Director of WES, a telephone call was received by MAJ G. L. C. Scott, Executive Officer, from COL W. D. Milne of Civil Works, OCE, during which inquiry was made as to the capability of WES to accomplish a study of underwater explosion phenomena and effects, particularly as relates to nuclear explosions. MAJ Scott learned that the study was to be made for the Armed Forces Special Weapons Project (AFSWP) of the Department of Defense (AFSWP was redesignated the Defense Atomic Support Agency (DASA) in May 1959). Subsequent conferences were held in the Pentagon offices of the AFSWP at which WES was represented by Messrs. J. B. Tiffany and F. R. Brown. On 26 January 1951, AFSWP announced the selection of the WES to accomplish the study. At WES, the study was assigned Job No. 2178, and because of certain classified aspects of the project, it was referred to simply as the "2178 study."

4. The manpower for accomplishing the study was provided by forming a special task group of engineers and technicians from personnel of the Hydrodynamics Branch, Hydraulics Division. At the time of formation of the task group, Mr. E. P. Fortson, Jr., was Chief of the Hydraulics Division and Mr. F. R. Brown was Chief of the Hydrodynamics Branch. Mr. G. L. Arbuthnot, Jr., was named project engineer and head of the task group.

5. Initial objective of the "2178 study" was to determine explosion-generated

water-surface wave heights as functions of time, distance from charge, and position of charge relative to the water surface for scaled water depths of 30, 60, 100, and 200 ft. The latter depth was chosen so as to be comparable to the water depth associated with the BAKER shot of Operation CROSSROADS.

6. A group of consultants met at WES on 5 and 6 February 1951 to review and to make recommendations relative to the WES proposed test plan. As the result of this and subsequent conferences, the scope of the study was extended to include measurements of airblast, water shock, and cratering of the basin's bottom.

7. The task of obtaining blast and shock measurements called for instrumentation equipment far beyond the capabilities of instrumentation at WES or, for that matter, packaged instrumentation available from private industry. It was therefore necessary for WES instrumentation personnel to develop the required instrumentation. Messrs. F. P. Hanes and L. H. Daniels of the Instrumentation Branch (WES) played a major role in the development of the sophisticated instrumentation system.

8. In the meantime, visits were made to other Government laboratories having experience in the field of blast and shock research, particularly the Naval Ordnance Laboratory and the Army's Ballistics Research Laboratories. Arrangements for these initial visits were made by Mr. H. J. Sundstrom, Civil Works, OCE, who assisted considerably in the establishment of contacts with several DOD agencies in the Washington, D. C., area. From these contacts a great number of reference materials were obtained as well as suggestions concerning gaging and overall testing techniques. Moreover, through these initial contacts the growth and development of the weapon effects group at WES have been sustained.

Major New Projects Assigned

Surface and underwater explosions

9. As mentioned earlier the initial study involved the determination of water-surface waves, water shock, and cratering produced by underwater explosions. It was soon evident that the results of these experiments would not provide a complete solution to the overall problem; consequently, as the capabilities at WES improved, major new projects were added in the area of surface and underwater explosions. The major new studies included shock wave propagation in deep and shallow water, effects of shock reflection from the bottom, shock attenuation characteristics of a bubble screen placed in the path of the oncoming shock waves, airblast and water shock characteristics of explosions at and slightly above the water surface, shoaling associated with waves advancing over the continental shelves, runup characteristics of waves on shore, and wave characteristics in the surf zone.

Surface and underground explosions

10. The NWED became considerably active in 1953 in the study of craters in connection with surface and underground explosions. These studies dealt primarily with

the size and shape of apparent and true craters, fracture zones and regions of upthrust, the boundary region between the plastic and elastic zones of the media, and an evaluation of size-mass distribution of ejecta as well as the trajectory of ejecta. During the studies of cratering phenomena, a new field of effort was initiated concerned with ground motion and stress measurements since these data were needed in connection with the design of underground protective structures. Since 1960, the NWED has participated in a number of laboratory as well as field tests for which the major objective was to determine the shock propagation characteristics of both soil and rock.

Protective structures

11. Work in the protective structures area began in 1956 with performance tests of buried, reinforced concrete arches. The arches were exposed to the blast and shock effects of the PRISCILLA Event of Operation PLUMBBOB which was conducted at the Nevada Test Site. Since that time efforts have been oriented toward the investigation of surface and buried structures of various geometric shapes. As the requirement for increasingly hard facilities evolved, research on protective structures became involved with high overpressure response and interaction studies and with structure efficiency and minimum-cost design.

12. In 1967, the responsibilities were broadened to include design and evaluation of protective structures for use by troops in the field as protection against conventional weapons. These studies support Armed Forces activities in Vietnam.

Studies in support of Vietnam

13. Since early in 1967, the NWED has conducted several high-priority studies in support of the Vietnam conflict. One such study examined various tunnel-destruction techniques with an aim toward developing an expedient solution followed by a more rigorous study of failure mechanisms and the most effective methods of destruction. A rather extensive study was conducted during the period September-December 1967 for the purpose of designing and proof-testing air-transportable personnel shelters. The proof-testing of shelters developed was accomplished successfully at Fort Benning, Georgia, in December 1967. Currently, the problem of protecting on-the-ground helicopters from small arms fire and rockets is under study.

Participation in field-test programs

14. Nuclear weapons effects tests. The NWED has participated in full-scale test events at the Pacific Proving Grounds and at the Nevada Test Site. Projects were manned by NWED personnel in the following operations and/or shots: Operation HARDTACK (several events), PLUMBBOB, DANNY BOY, JOHNIE BOY, SMALL BOY, PIN STRIPE, NEW POINT, TINY TOT, DISCUS THROWER, and LONG SHOT.

15. High-explosive test programs. The following high-explosive field tests were supported by one or more NWED projects in each test operation: Greenland Tests (six test seasons, 1957-1962); high yield shots at Canada's Defence Research

Establishment, Suffield, i.e. Operation SNOWBALL and Operation DISTANT PLAIN; other field-test participation has included Operation MINE SHAFT, Sevier Bridge Reservoir 45-ton Experiment, Operation BACK FILL, HEST Demonstration Test, and HEST V.

Improvements in Techniques

Approach to research

16. Through the years, there has evolved a decided emphasis on formulation of a theory (or hypothesis) pertinent to phenomena under study prior to the conduct of experiments. This trend has resulted in greater understanding of analytic methods and the decisive role such methods can play in developing rigorous solutions or in defining nonlinearities at least as to character or cause. Mr. Jesse Kirkland was responsible initially for the development of these analytical techniques.

Instrumentation

17. Although the WES had considerable capability in instrumentation techniques in 1951, sufficiently high-frequency-response systems for monitoring the effects of explosions were not available. It was therefore necessary to design and build an instrumentation system for obtaining measurements of shock (in water) and blast (in air) to include accurate recording of the almost instantaneous rise time associated with shock wave arrival. The initial components were designed mainly by the efforts of Dr. A. B. Arons, Consultant to WES on shock phenomena, and by Messrs. L. H. Daniels, W. B. Slay, F. P. Hanes, and L. F. Ingram of the WES Instrumentation Branch.

18. Through the years, improvements in the system were effected through modification of the basic electronic circuitry and by adding components that had been improved by succeeding generation developments.

Blast simulation devices

19. A number of devices have been developed for laboratory simulation of certain explosion effects for purposes of studying free-field and response behavior of earth and construction materials and to study response of structures and structural components.

20. Blast load generators. The Large Blast Load Generator (LBLG), a device for producing loads up to 500 psi simulating the pressure signature of megaton weapons over a soil sample 23 ft in diameter and 10 ft deep, was operationally proof-tested in 1963 and is considered a major breakthrough in the development of laboratory blast-loading equipment. Along with this development a small (4-ft diam) blast generator was placed in operation which provided blast loads up to 225 psi. These operations were hampered considerably by difficulties in placing a uniform soil sample as well as the placement of test structures in the sample. However, during 1964 and 1965 through the efforts of Messrs. Paul Hadala, Darryl Hale, Ed Perry, Leo Steen, and others, techniques for placing sand in the blast load generators and flexible, metal cylinders in a clay specimen were developed, making it possible to

conduct tests of certain classes of buried structures. In 1966, primarily through the efforts of Mr. Hadala, a technique for installing a greased liner in the Small Blast Load Generator (SBLG) was developed that significantly reduced sidewall-friction effects, thus making it possible to test larger structures and longer soil samples, and to evaluate free-field stress gages.

21. Ram-type loaders. In 1966, another important event occurred with the successful installation of both the 200- and 500-kip ram-type loaders, which are devices for applying dynamic loads to structural specimens (slabs, beams, etc.). On 24 April 1968, a deep slab 30 in. in diameter was tested in a new high-pressure loading device to a static overpressure of 13,000 psi which is believed to be the highest pressure attained for a specimen of this size.

Significant Technical Results

22. Since the beginning of the explosion effects research program at the WES, many significant technical achievements have been made. With the support provided by other WES elements, notably the Instrumentation Branch and the Soils Division, the NWED has developed a strong capability in the field of weapons effects. This capability is founded on knowledge and experience gained over a period of 17 years of intensive study relating to airblast, water shock, water-surface waves, cratering, ground shock and motions, nuclear radiation, and protective structures research.

23. Test facilities have been obtained, devised, and improved such that modeling and simulation are used effectively to solve specific problems with relative accuracy. The major consideration in this regard is the improvement of instrumentation equipment including sensors and electronic recording systems. In many cases the state-of-the-art electronic equipment was not available commercially; therefore, it has been necessary to conceive, design, and develop special instrumentation. Several transducers for measuring blast pressures, water waves, stresses, and motions fall into the latter category. This equipment, together with an attendant personnel capability development, is such that we can respond to the needs of the Services and the DOD for fielding and conducting major experimental programs. For example, during calendar year 1968, we will participate in approximately seven major effects experiments (away from Vicksburg) which will involve structural component testing as well as basic phenomenology measurements.

24. In the field of water shock propagation, we have been successful in determining shock attenuation rates for a wide range of water depths, charge positions, and distances away from the charge. In fact, the only information on water shock waves in shallow water (30 to 60 ft deep) is that developed by the experimentation program carried out at WES in the middle 1950's.

25. During the period 1965-1967, a theoretical study was accomplished by Dr. A. Sakurai which enables one to predict pressure-time histories at various

spacial locations underwater from an above-surface explosion, thus effectively solving the air-induced water shock problem. Subsequently, the problem was coded for an electronic computer solution. More recently the problem of treating a water-surface explosion was attacked theoretically by Dr. Sakurai. The theoretical results agree very well with experimental results for charge weights in a range of a few tens of pounds of TNT. Verification experiments for higher yields are planned.

26. As a result of studies of the shock attenuation characteristics of air bubble screens, it was determined that such screens can be very effective for reasonably large, high explosive charges; however, their applicability to very large explosions (nuclear range) was shown to be ineffective (the latter inference having been made by theoretical calculations).

27. The WES has contributed significantly to all phases of the explosion-generated water wave problem. The effect of charge depth of submergence on wave magnitude at various ranges from surface zero as well as the attenuation rates for wave amplitude have been established. The existence of the high wave (or surf zone) problem came to light as the result of the experimental program carried out at MONO LAKE during 1965. Subsequent analytical calculations have further defined the environments where the high wave problem is expected to be severe.

28. Efforts in the field of explosion cratering have been extensive since 1952. Crater studies have been carried out in a wide range of soil types including rock as well as snow and ice. Results of these studies along with those of other laboratories and agencies have led to the wide acceptance of the cratering problem as being highly significant in dealing with the design of hardened underground structures. Unique evaluation techniques were developed for assessing explosion effects such as the delineation of the true crater, direct measurement of the close-in subsurface displacement, definition of the upthrust zone, and the extent rupture. Moreover, it is believed that WES was the first to make use of aerial stereophotography to obtain rapid measurements of the apparent crater and the extent of throwout material.

29. A major technical contribution has been made in advancing the understanding of blast and shock phenomena (underground) and in methods of measuring such mechanical effects of explosions. With the possible exception of the Stanford Research Institute, no other organization in the United States is more sought after than the Physical Sciences Branch of NWED to accomplish field measurements of earth stress and motions. Numerous field tests have been accomplished for DOD as well as all three Services to measure, interpret, and analyze these data from near-surface and underground explosions. The same group, with the assistance of Soils Division personnel, made notable strides in determining the effects of earth material properties, including geologic layering, on stresses and motions. With the assistance of the Instrumentation Branch, they have been instrumental in development of a family of soil stress gages for use in free-field and on-structure (flush-mounted)

measurements. A continuing evaluation program has resulted in selection of the best available commercial acceleration and pressure transducers for blast and shock measurements. In addition, transistorized signal conditioning modules have been designed and constructed for use with direct-current and carrier system gages.

30. In the field of protective structures, the conception and finally placing into operation of the LBLG facility has made possible a versatile program of research. Without simulation testing, research in this general area would have lagged, particularly since the nuclear test ban became effective. The LBLG is a proven test facility for reproducing airblast load environments for embedded structures up to an airblast pressure of 500 psi. Through tests accomplished in the LBLG and other laboratory loading devices, soil arching phenomena have been documented. An empirical method has been devised that permits prediction of active and passive arching up to surface overpressures of 200 psi for structures buried in sand for which the angle of internal friction and constrained modulus are known. These tests have also pointed out that the beneficial effects of arching in clays are much less than in sands. Similar tests conducted on buried cylindrical-type structures have shown that dynamic strains are from 20 to 40 percent greater than strains developed by an equivalent static load; again, there was a drastic difference in the response of similar cylinders tested in sand and clay in that structures buried in sand could withstand much greater overpressures for comparable depth of burial. Dynamic tests of semicircular concrete arches of various stiffnesses have determined that loading on the arch approaches a hydrostatic case, that the thrust was uniform around the arch, and the only significant bending moments occurred at the crown of the arch. Most recently, a series of studies has been initiated to determine the feasibility of using the principles of similitude in testing buried underground structures. Significant results have already been noted; for example, the dynamic structural response, i.e. strain, thrust, moment, and deflections, as well as motion (acceleration and velocity), has scaled according to the general similitude theory for model arches up to a length scale ratio of 9.

31. In support of the Office of Civil Defense, airblast load tests were conducted on three series of simply supported, two-way reinforced concrete slabs designed for live loads of 105, 165, and 225 psf. It was found that uniformly distributed static loads required to cause collapse were approximately 8 to 10 times greater than the design live loads; dynamic airblast loads required to cause collapse ranged from 1.27 to 1.44 times the uniformly distributed static loads. The limiting midpoint deflections of the slabs under blast loads are in good agreement with those predicted by the design equations of ASCE Manual No. 42.

Major Changes in Organization

32. As stated earlier, the first study of nuclear weapons effects at WES was

initiated by a small group of personnel selected from the Hydrodynamics Branch, Hydraulics Division, and was headed by Mr. G. L. Arbuthnot, Jr. General supervision of the group was vested in the Chief, Hydrodynamics Branch, Mr. F. R. Brown. Enlargement of the study's original scope made it evident that the study would require more than the original estimate of one year to complete; in addition, it became apparent that the group would be called upon to do other studies in the same field. Therefore, in June 1951, the Hydrodynamics Branch was reorganized to add a new element, the Special Investigations Section, in which the weapon effects group was placed.

33. The Special Investigations Section continued to function until 1962, during which research efforts expanded dollarwise from the initial $100,000 to about $900,000 annually. A total of 38 personnel were assigned by this time. To provide for further expansion in technical capabilities and proper management, the Special Investigations Section was upgraded in February 1962 to form the Nuclear Weapons Effects Branch, Hydraulics Division.

34. At the beginning of Fiscal Year 1964, it was decided that two new technical divisions would be organized at WES. This change resulted from rapid expansion of activities in the Nuclear Weapons Effects Branch as well as the addition of considerable mobility and environmental research being carried out by the Soils Division. As the result of this reorganization, the Nuclear Weapons Effects Division (NWED) was formed on 12 July 1963. Mr. E. P. Fortson, Jr., Chief, Hydraulics Division, was appointed Acting Chief, NWED, until 26 November 1963 at which time Mr. F. R. Brown (formerly Chief, Hydrodynamics Branch, Hydraulics Division) was appointed Chief, NWED. Mr. G. L. Arbuthnot, Jr., was appointed Assistant Division Chief on 9 October 1964, Acting Division Chief on 14 December 1964, and Division Chief on 10 July 1966, thus replacing Mr. Brown.

35. Since the organization of NWED in 1963, only one major adjustment to the organization has been effected. This change was made 8 January 1968 and involved the disbanding of the Analytical Section, Physical Sciences Branch, and all Sections of the Protective Structures Branch. The Analytical Section was reorganized to form the Analytical Research Group under direct control of the Division Chief; the sections within the Protective Structures Branch were formed into an Operations Group and a Projects Group.

36. As of 15 April 1968, total personnel of NWED was 88 and the fiscal budget for FY 1968 was approximately $4.5 million. Organization and personnel assignments are shown on the following page (fig. VIII-1).

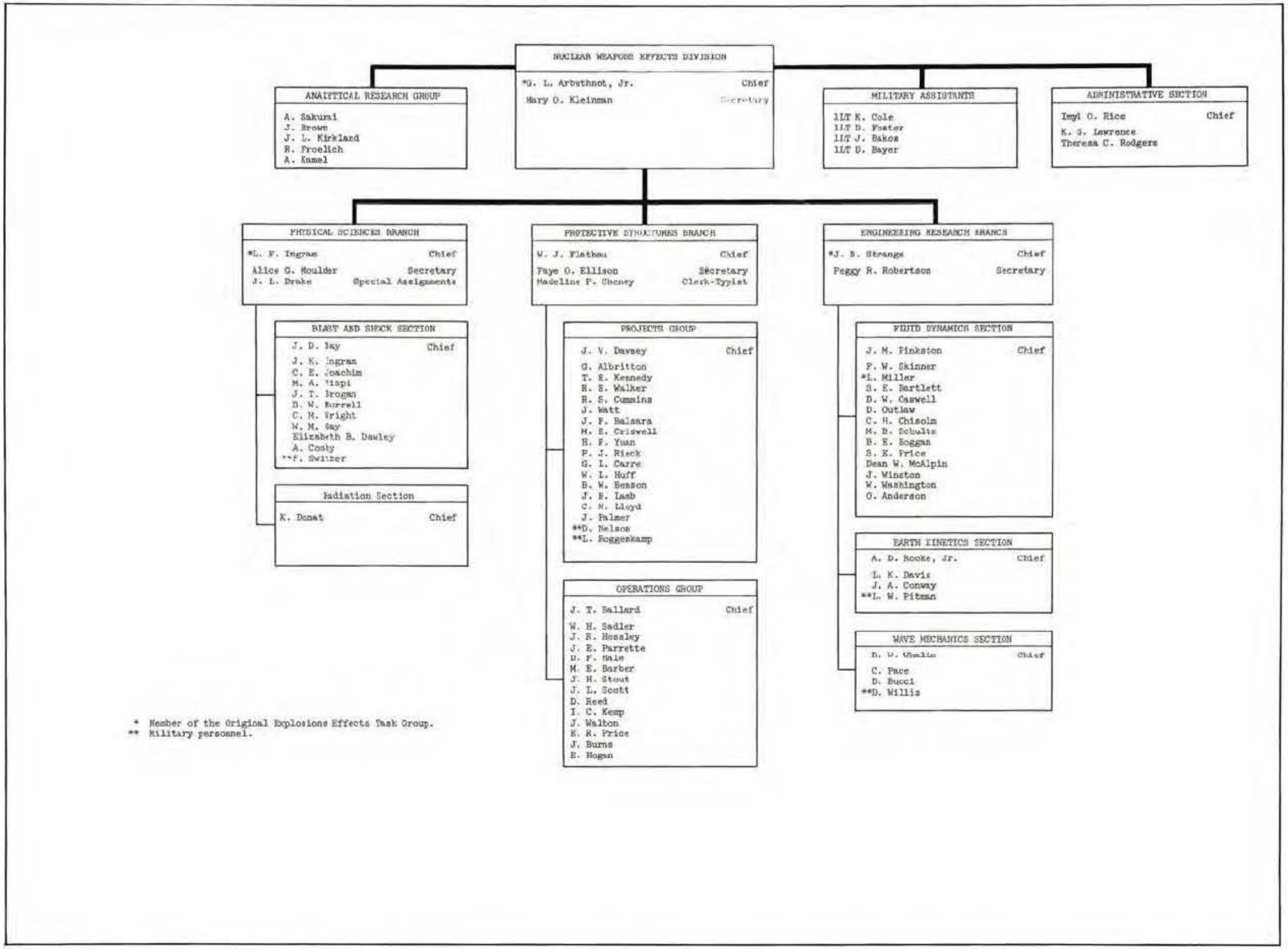

Fig. VIII-1. Organization chart

Appendix IX
MOBILITY AND ENVIRONMENTAL DIVISION

1. The Mobility and Environmental (M&E) Division was established in July 1963 from elements that had been a part of the Soils Division. Thus, to trace the history of the M&E Division, it is necessary to go back to the origins and development of those work programs and associated organizational elements in the Soils Division which later formed the M&E Division.

2. The first mobility work at WES, then called trafficability of soils, had its beginning in the spring of 1945. At that time, near the end of World War II, an invasion of Japan appeared imminent, and solutions were needed to the problem of travel of military vehicles across Japanese rice paddies. The immobilizations that had occurred in the mud of Italy, the beach sands of Iwo Jima, and the rice paddies of Okinawa lent urgency to the task of developing techniques for assessing off-road mobility. The atom bomb made invasion of Japan unnecessary; but continued world crises have intensified the interest in off-road mobility, and the program at WES has prospered.

3. To initiate the work in 1945, there was created in the Flexible Pavement Branch of the Soils Division a Trafficability Section with O. B. Ray as chief. Because of the urgent nature of the program, a large staff consisting of 11 professionals, 21 subprofessionals, and 1 laborer was assigned, and the work was conducted on a round-the-clock, seven-day-a-week basis. A report, "Trafficability of Soils," was published to meet the deadline of 1 September 1945. The chief conclusion of this report was that "the cone penetrometer is a satisfactory reconnaissance instrument for determining the stability of muds." The report recommended a deliberate program of research to shed further light on the highly important military problem in trafficability of soils. This report was favorably received by the Engineer Board (which sponsored the work) and the OCE, and in 1946 OCE assigned a continuing project, "Trafficability of Soils as Related to the Mobility of Military Vehicles," to WES.

4. The first studies under the new project consisted of tests using actual vehicles traveling on prepared fine-grained soil test lanes built in the vicinities of Vicksburg, Mississippi, and Yuma, Arizona, in 1946, 1947, and 1948. These tests demonstrated a high degree of correlation between cone penetrometer readings and vehicle performance on a "go" or "no go" basis, thereby reinforcing the conclusion that the cone penetrometer was a satisfactory device for evaluating vehicle performance. In the spring of 1949, the first major tests on natural soil conditions were conducted in the vicinity of Vicksburg. These tests revealed that certain soils, when very wet, lose a high percentage of their original strength under a moving vehicle. Thus, while cone penetrometer measurements had been adequate to describe soil strength in prepared test lanes (where the soils had been extensively reworked),

it was apparent that, by themselves, cone indexes, as they came to be called, were not sufficient to describe the effective strength of natural soils. Accordingly, a major program of tests on natural soils with prototype vehicles was begun near Vicksburg and Laurel, Mississippi, and later extended to several widely scattered areas in the U. S. The result of these efforts was that by 1951 there was ample evidence that vehicle performance could be predicted reasonably well if a measure of the expected soil strength change, called remolding index, was combined with cone index.

5. Exploratory work was started in 1948 to develop soil-moisture-strength prediction methods for trafficability on a worldwide basis. The prediction program received impetus in 1950 and resulted in a cooperative study with the Forest Service, U. S. Department of Agriculture. The Forest Service established the Vicksburg Infiltration Project at WES in 1951. It operated under the successive leadership of E. J. Dortignac, H. W. Lull, J. S. Horton, H. D. Burke, and F. W. Stearns until 1961, when the cooperative effort was terminated. The prediction work, which continues to the present time, was an embryonic manifestation of the large program in terrain analysis which the M&E Division now conducts.

6. In 1949, O. B. Ray was made chief of the large, newly created General Investigations Section in the Flexible Pavement Branch, and S. J. Knight, who had been in the Trafficability Section since 1946, was appointed chief of that section.

7. In 1953, a conference was held at WES between representatives of the Navy Department and OCE and selected consultants to consider the problems associated with the trafficability of coarse-grained soils. By mutual consent, responsibility for research into these problems, formerly considered to be the Navy's, was assumed by OCE (and WES). A pilot study, in which D. R. Freitag played a prominent part, was begun almost immediately. The vehicle tests in this program indicated that good relations existed between cone index and vehicle performance. Follow-on tests, mainly on beaches but also on desert areas, firmly established these relations.

8. In 1954, WES was assigned studies in the trafficability of snow. Considerable field work with actual vehicles was performed in Greenland in the summers of 1954, 1955, and 1957 and in Canada and the U. S. in winters through 1958. Analysis of this work indicated the utility of the cone penetrometer as a field device for the measurement of the in situ strength of snow and provided a good basis for a simple scheme for the prediction of vehicle performance.

9. Also in 1954, the need for more fundamental studies in mobility was recognized, and investigations were conducted in conjunction with vehicle trafficability tests. It was soon realized that special facilities for scale-model testing would be needed, and in September 1956 a site for a small-scale testing facility was selected. Since then the original small-scale facility has been expanded and another large facility for testing prototype vehicles has been added.

10. In July 1959, an important milestone was reached when an Army Technical

Bulletin, TB ENG 37, "Soils Trafficability," was published by The Engineer School. This bulletin, actually written at WES, described the equipment and the procedures required to predict the performance of vehicles in fine-grained soils. This bulletin has been widely used by the military and, since it also includes crude design information, by some vehicle manufacturers. It is no longer published, but its contents are currently (1968) being incorporated into Army Technical Manual 5-330, "Planning and Design of Roads and Airbases in the Theater of Operations."

11. The organizational structure described above was maintained until 1956, at which time the Trafficability Section was redesignated the Army Mobility Research Center in keeping with the increasing recognition of the need for more basic studies in mobility; S. J. Knight continued in charge. In 1958, the Army Mobility Research Center was given branch status in the Soils Division; S. J. Knight was designated as branch chief and also as chief of a newly established Mobility Section. The Trafficability Section was reestablished with A. A. Rula as chief. D. R. Freitag was appointed chief of the Mobility Section in 1960, and in that same year the Terrain Analyzer Section was added with E. B. Lipscomb as chief. This latter section came into being because of the interest in remote sensing methods for rapid evaluation of trafficability conditions over large geographic areas; this work represented an extension of WES capabilities into the fields of infrared, radar, gamma ray, and other electromagnetic sensors.

12. The year 1961 saw an expansion of the trafficability program into a study of organic soils (muskeg); in this and succeeding years considerable field testing was accomplished, principally in Canada. Also in 1961, D. R. Freitag started a year in residence at Auburn University on a Secretary of the Army Research and Study Fellowship; J. L. McRae served as Acting Chief of the Mobility Section during his absence.

13. Increased emphasis by the Army on tropical studies starting in 1962 led to the establishment of separate elements in the Soils Division devoted to the extension of soil-moisture-strength prediction methods in the American tropics. Tropical Terrain Research Detachments conducted studies in the Panama Canal Zone under M. A. Zappi and in Puerto Rico under B. O. Benn. The Canal Zone studies were phased out in February 1964, but the Puerto Rico Detachment is still in operation (1968).

14. The foregoing organization remained in effect until 1963, when the M&E Division was established.

15. It is now appropriate to go back and trace the development of the other major programs in the Soils Division that eventually became the "environmental" part of the M&E Division. This work had its inception in the projects "Environmental Analogs" and "Evaluation and Presentation of Changing Environmental Factors," which were conceived by Dr. Paul Siple, then Chief of the Environmental Section, Research and Development Division, Office of the Assistant Chief of Staff G-4, U. S. Army. WES was requested in 1952 to conduct these projects, and they were assigned to the

Project Investigations Section of the Embankment and Foundation Branch. A. A. Maxwell was chief of the section and J. R. Compton was the sole engineer assigned to carry out the work. The object of the studies was to develop techniques for evaluating the environmental conditions affecting military operations in different areas of the world and to translate the information into forms useful for military commanders and planners.

16. The early efforts in these studies were largely carried out by contracts with universities and other agencies, both governmental and private. The Geology Branch of the Soils Division under J. R. Schultz and later under C. R. Kolb contributed in a large measure to the studies. Extensive use was made of a group of consultants to provide advice concerning the nature of the studies that should be pursued and to evaluate results.

17. In 1954, the two initial projects were combined into one titled "Military Evaluation of Geographic Areas" and the environmental program had progressed to the point that a permanent staff seemed necessary; therefore, the Area Evaluation Section with J. R. Compton as chief was established in the Embankment and Foundation Branch. In addition to the chief, the section had two employees. The first years of the project were plagued with numerous futile efforts to achieve meaningful direction to a very complex problem, with funding problems, and with high-level efforts to discontinue the program completely. However, a stabilized program and firm sense of direction were eventually achieved. In 1961, W. E. Grabau replaced J. R. Compton as Chief of the Area Evaluation Section. In-house capabilities were gradually increased until in 1963 there were five employees in the section.

18. The gradual increase in work load at WES resulted in a decision in 1963 to establish two new technical divisions, of which one was the Mobility and Environmental Division. W. J. Turnbull was designated Acting Chief (in addition to his assignment as Chief, Soils Division) and W. G. Shockley was named Acting Assistant Chief of the new division; Shockley was made Chief of the M&E Division in November 1963. The new division incorporated the Army Mobility Research Branch (redesignated from the Army Mobility Research Center) with S. J. Knight as chief, and contained a Mobility Section, D. R. Freitag, chief; a Trafficability Section, E. S. Rush, chief; and a Terrain Analyzer Section, with the chief position vacant since the transfer of E. B. Lipscomb earlier in the year. The Area Evaluation Section was redesignated the Area Evaluation Branch with W. E. Grabau in charge and contained two sections, the Field Test Section and the Overseas Section; both chief positions were vacant. The Tropical Terrain Research Detachments in Puerto Rico and the Panama Canal Zone were incorporated originally as separate elements; but after the phasing out of the Panama Detachment in 1964, the Puerto Rico Detachment was placed under the Area Evaluation Branch. The Division had a small Administrative Section with C. V. Davidson as chief.

19. An entirely new branch, the Mobility Environmental Research Studies

Branch, with A. A. Rula as chief, was formed as part of the new organization. This was occasioned by the assignment of the Mobility Environmental Research Study (MERS) to WES by the Advanced Research Projects Agency in March 1963. The MERS project was a significant effort covering an approximate three-year period to study the physical environment of Southeast Asia, particularly as it related to the off-road mobility of military vehicles. Much of the basic work on the project, especially vehicle tests, was done in the U. S. by WES personnel with some assistance from contractors and other Government agencies. Work in Southeast Asia was concentrated in Thailand where extensive environmental measurements and some vehicle tests were made. The MERS Branch was essentially a small management group drawn from within the M&E Division to plan and direct the program. Work assignments were made to other organizational elements as appropriate. The work in Thailand was accomplished on a task basis using WES personnel as team leaders and Thai engineers and technicians as assistants. To ensure continuity of operations overseas, a Thailand Detachment was established with LTC A. R. Simpson in charge; his principal civilian assistants were E. E. Garrett and later B. O. Benn.

20. Needless to say, in the years 1963 through 1965, the major effort in the M&E Division was concentrated on the MERS project and the basic programs of the Division were carried on at a minimal level. Key personnel changes that occurred during this period were: S. J. Knight was appointed Assistant Division Chief and D. R. Freitag replaced him as Chief of the Army Mobility Research Branch; B. R. Davis was named Chief of the Terrain Analyzer Section and J. K. Stoll was designated Chief of the Field Test Section; W. M. Rushing replaced B. O. Benn as head of the Puerto Rico Detachment when the latter was transferred to Thailand; C. H. Mackey replaced C. V. Davidson as Chief of the Administrative Section.

21. The phasing out of the MERS project in 1966 necessitated a change in organization in the Division since the MERS Branch was no longer needed. At the same time it was recognized that over the years a number of activities which had been carried on in certain sections and branches were more closely related to work in other organizational elements. Therefore, it was decided to reorganize the entire Division in order to place related work in the same organizational elements insofar as possible. The reorganization was accomplished in August 1966, and the resulting structure is shown in fig. IX-1. Key personnel changes in this period were: succeeding W. N. Rushing in the Puerto Rico Detachment were A. P. Desmarais and later J. D. Broughton; H. H. Green replaced C. H. Mackey as Chief of the Administrative Section.

22. The projects assigned in the early days of trafficability, mobility, and terrain analysis studies were sponsored by the then Research and Development Division of OCE. With the formation of the Army Materiel Command (AMC) in August 1962, these projects were transferred to AMC but the work continued at WES under a special working agreement between OCE and AMC. In addition to the continuing AMC program, the Division has undertaken work for the Advanced Research Projects Agency, the Navy,

the Air Force, the National Aeronautics and Space Administration, and other Government agencies. A measure of growth of these activities since the first trafficability work in 1945 may be obtained by comparing the 33 people and $67,000 in that year with 114 people and an expenditure of about $2,600,000 in fiscal year 1967.

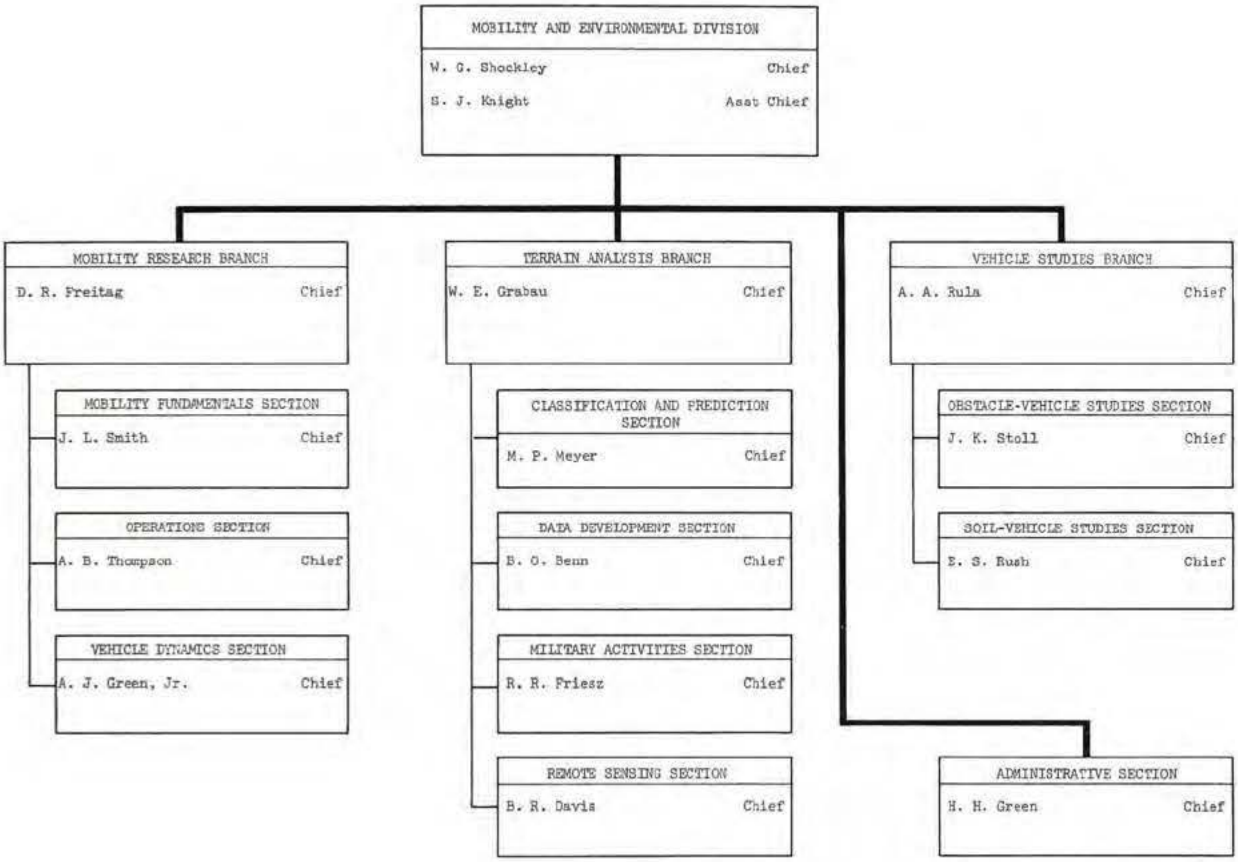

Fig. IX-1. Organization chart, August 1966

Appendix X

TECHNICAL SERVICES DIVISION

1. Facilities of the Technical Services Division are organized under central management to provide essential technical support to engineering research divisions in accomplishment of the WES mission, and to perform directly for the Corps of Engineers such assignments as may be within their capabilities. Strength and composition are modified as necessary to accommodate current and projected work requirements of both types.

2. This Division was first established in late 1949 to bring together as a coordinated operation the several specialized units providing common support to Hydraulics, Soils, and Concrete Research Divisions at the time. Supervision was assigned as a dual responsibility to J. B. Tiffany, Special Assistant to the Director. Included in the original organization were the Corps of Engineers Research Center (Technical Library, Reports Branch, Engineering Branch) under C. B. Patterson, the Reproduction Branch (Printing Plant, Drafting and Photography Sections) under J. M. McCaskill, the Instrumentation Branch (seven task-oriented sections) under E. H. Woodman, and the then Training and Information Branch (visitor reception and training administration functions) under C. H. Lefeve.

3. In late 1950, C. B. Patterson was made Chief of the Technical Services Division, thereby relieving Mr. Tiffany for full-time attention to his primary executive functions. Shortly thereafter, the Reports Branch (including Publications Distribution Section) was transferred from the Research Center to the renamed Reproduction and Reports Branch to combine as an integrated operation all related activities concerned with the preparation and processing of technical reports. The seven subdivisions of the Instrumentation Branch were reorganized to form three functional sections. All elements except the Instrumentation Branch were housed together in two wings of the Administration Building (later destroyed by fire), and no other significant organizational changes were made until the addition of a fifth branch, the Electronic Computer Branch, in 1957.

4. In September 1957, the Computer facility became operational with full equipment and minimum staff in the Administration Building. Division operations and staffing increased in an orderly manner until severely disrupted by the 3 October 1960 fire.

5. Any historical account of the Technical Services Division must record the 1960 fire as a most significant chapter. Although certain administrative units were displaced and their record files lost, the Technical Services Division was the only major operating element so affected. With the exception of the Instrumentation Branch, all elements of the Division were completely burned out, including work space, furniture, record files, library collection, and very costly equipment which--with the building itself--comprised the bulk of the direct financial loss. The displaced

staffs had concurrently the dual burden of restoration planning as well as carrying on their regular work with such facilities as could be acquired in widely dispersed temporary locations. To the credit of all concerned, this was effectively accomplished. Recovery operations are further described in sections of this history pertaining to the individual units concerned.

6. During planning and construction of the (present) Headquarters Building designed to house them, elements of the Technical Services Division operated at scattered locations about Vicksburg. The Computer Branch operated from the basement of the Peeples-Newman Building downtown. The Reproduction and Reports Branch (less the Photo Lab) and the Research Center (less the Library) operated from the old MRC Headquarters Building and a transit shed in the National Military Park. The Photo Lab operated from hastily erected cover on part of a wing of the burned-out Administration Building. The Library was located in a frame house (subsequently razed) near the site of the new Headquarters Building. The Instrumentation Branch continued to operate from a frame building constructed to house shops activities in the original WES installation. The Technical Liaison Branch, as it was now named, was appropriately transferred from the Division to the advisory staff.

7. With occupancy of the present Headquarters Building in 1963, all elements of the Technical Services Division were housed together in the same location on the Vicksburg reservation. Shortly thereafter the Reproduction and Reports Branch was transferred to the administrative staff, and the Technical Services Division thenceforward has consisted of the three Branches whose histories are summarized below.

Research Center

8. The evolution of separate activities that were later to make up the present Research Center is somewhat obscured by the passage of time and a lack of precise records. A Soils Research Center was authorized in August 1936 for the purpose of gathering and disseminating soil mechanics information. It was established as a collateral agency of the Soils Laboratory Testing Section, with Robert M. German in charge. A Hydraulics Research Center was authorized in September 1937 to assemble experimental hydraulic data from all available sources and to interpret the data and disseminate information to Division and District offices. This activity was operated under George W. Howard in parallel with the various hydraulic model investigations under way at the time. Although translation and library functions were assigned, the Library remained for several years a small office collection of books and reports maintained as part of the overall administrative complement by Claude C. Lee and one clerical assistant. There was no central organization for the processing of reports.

9. For a brief period just prior to World War II the two organizations were merged to form the Engineer Department Research Center, first under LT Wright Hiatt

during CPT Fields' administration, and then under Samuel Shulits. By this time the translation function had become productive and H. B. Edwards served as Translator in the several languages and disciplines involved. The Library, although receiving some engineering guidance, was still shown as part of the then Administration Division.

10. During World War II nothing was active but the Library and the one translator. By this time, however, a number of translations had been prepared, the Quarterly Summary had been initiated, and 15 Soil Mechanics and 11 Hydraulics Bulletins had been published. Costs, largely subsidized by the MRC and Station overhead, varied from some $16,000 in 1938 to $46,000 in 1942.

11. Upon his return in mid-1946 from duty as a Field Artillery officer in the Pacific Theater of Operations, C. B. Patterson was assigned by COL Newton, then Director, responsibility for reactivating the Research Center as a central source of technical information for the Experiment Station and the Corps of Engineers in the civil works fields represented. In addition to the translation, exchange, special publications, and model-prototype confirmation features comprising an Information Service, the principal components were to be a first-class reference library and a central facility for standardizing, editing, and preparing copy for the numerous technical reports either backlogged during the war effort or expected to result from renewed national interest in civil works construction.

12. During the organization phase, Katharine H. Jones was assigned to head and develop the Reports Branch, and C. F. Johnson with the (Publications) Distribution Unit was transferred from Office Services to this Branch. WES was made a sales agent of the Superintendent of Documents. In mid-1947 the Library, which had been administered as an office collection under Katharine McDiarmid, Ruth Heisey, and Lucille Woodson in turn, was designated the central reference library of the Corps in the subject fields of local interest. The broader library mission called for thorough reorganization, proper staffing, and definite operating procedures in order to create a facility adequate to the assigned needs. Alan G. Skelton, present Head Librarian, was recruited and given this responsibility. Jan C. Van Tienhoven, present Translator, was recruited to fill the vacancy left by the unexpected death of Mr. Edwards. William B. Tanner was made Chief of the Research Center, with Information Services under William W. Geddings. Model-prototype confirmation studies were absorbed in Hydraulic Analysis activities of the Hydraulics Division.

13. From that time and continuing to the present, Research Center activities have resulted in a large number of reviews, analyses, and searches for technical information; over 200 translations; establishment of some 59 foreign and 43 domestic publications exchange agreements; lists of recent library acquisitions; List of Definite Project Studies; various Miscellaneous Papers; comprehensive bibliographies; Combined Series WES Bulletins (initiated in 1947--discontinued in 1954 due principally to lack of funds); Annual Summary (successor to earlier Quarterly Summary); distribution and sale of many thousand publications; and greatly expanded library

services. Research Center operations are funded by the Civil Works Directorate of OCE under the Engineering Studies (formerly Civil Works Investigations) Program, plus (since 1960) direct charges to military accounts for their equitable share of the services rendered. Costs have varied from some $60,000 in FY 1949 to $145,000 (plus $115,000 Military) in FY 1968.

14. A Specifications Section, designed to aid the Military Construction Directorate of OCE in keeping up with changes in guide specifications and referenced publications for civil and military construction, was added to the Research Center in February 1961. This section has been headed since its inception by Virginia Dale, assisted by Marjorie Carlson and Bettie Ransome. Financed by MCA funds, the costs have increased from $27,000 in FY 1962 to $37,000 in FY 1968.

15. As the largest and most rapidly growing element of the Research Center, and the function most seriously affected by the 1960 fire, the Library merits special mention.

16. In the fall of 1947 definite steps were taken to fulfill the Library's expanded mission and a detailed reorganization plan was developed by Alan G. Skelton, Technical Librarian, and C. B. Patterson, then Chief of the Research Center. The Library was functionally divided into reference and cataloging departments, the collection was screened for elimination of useless items, and recognized standard library practices were put into effect. During the next several years great progress was made in development of the collection and recruiting of an adequate staff. By 1960 the collection included more than 50,000 accessioned items as well as several thousand unaccessioned copies of periodicals, reprints, reports, etc. Supplementing this was an outstanding card catalog index of some 275,000 cards (many containing abstracts) alphabetically arranged by subject, author, series, etc. Some 7000 references were on loan each day in approximately 40 states.

17. In the 1960 fire all of the collection was lost except for about 10,000 items that were out on loan at WES or elsewhere. The greatest loss, however, was loss of the card catalog index, which represented 13 years of effort and without which the collection could not be properly used. The Library was reduced in one night from one of the outstanding engineering libraries in the Southeast to a scattered, small collection of unindexed books.

18. During the intense rehabilitation program begun immediately after the fire, the Library staff was divided into two groups: one which attempted to give service with its limited resources to the Corps of Engineers, and another which concentrated on the acquisitions and reprocessing program. Funding in the amount of $328,000 was provided by OCE for Library rehabilitation. During the months that followed, monthly acquisitions ranged from as many as 9100 in March 1961 to as few as 950 in November 1963, and by 1964 some 120,000 individual items had been obtained through purchase, gift, and exchange. (Gifts were so generous that only one out of seven publications had to be bought.) The monthly acquisition rate, when

compared to the rate of less than 1000 new publications per month prior to 1960, illustrates the impact of this acquisitions program on the processing requirement. Of some assistance in the rebuilding process was a Library Advisory Board, temporarily constituted to include technical representatives from using divisions, that advised the Library staff on references to be acquired in order for the collection to meet present and future needs.

19. Following rehabilitation the Research Center Library resumed its position of serving the Corps of Engineers as the central reference library in the fields of hydraulics, soil and rock mechanics, flexible pavements, expedient surfacings, concrete testing, mobility of military vehicles, nuclear weapons effects, environmental studies with military applications, engineering geology, and related subjects. Along with being a research library, it functions also as a bibliographic center by reason of its having the catalogs of eleven other similar organizations, foreign and domestic, which are of great value in engineering research. There are more than 500,000 reference cards in the actively growing files, and more than 1500 reference items are received each month and incorporated into the collection of some 200,000 items. Materials are presently on loan in 40 states and 7 foreign countries and are being used by 115 Corps of Engineers offices, Government agencies, and other installations. The daily number of items on loan now numbers more than 17,000. Complete microform facilities are now available. The Library will assume a critical support responsibility when Information Analysis Centers are established at WES in the near future as planned.

Electronic Computer Branch

20. In early summer of 1957, it was learned that an IBM-650 computer would become available for rental, and the decision was made for WES to acquire this machine and apply the new technology to computation of scientific and engineering problems for WES and the Lower Mississippi Valley Division and its Districts. Early in July C. B. Patterson was assigned, in addition to normal duties, personal responsibility for planning the new facility, recruiting the programming and operating staff, arranging programming training for user engineers, selecting peripheral equipment, preparing the site, obtaining supplies, determining operating procedures, and having enough problems programmed by the delivery date of mid-September to provide at least 50 percent prime-shift utilization. He was assisted in an outstanding manner by two Army enlisted men, PFC Edward V. Resta and PFC Stephen A. Closs, who were transferred to WES for this task because of their previous acquaintance with IBM-650 equipment. Two key-punch and EAM operators, Bernadine Reynolds and Alice M. Woody, were recruited. The impossibly short deadline was successfully met, and so began the first digital computer center in the State of Mississippi.

21. As the facility became operative, Donald L. Neumann (present Chief) was recruited from the St. Louis District to head the organization; Arthur L. Gilmore, an experienced mathematician-programmer from Eglin Field, was recruited to head the programming staff; James B. Cheek and Henry W. Heslin were assigned as staff programmers; Harley C. Pierce was recruited for machine room operation; and it is this highly competent cadre that has enabled the Computer Center to develop in pace with the vastly increased requirement for machine computation since that time.

22. Processing of engineering and scientific work for WES and LMVD, on a cost-and-time sharing basis, continued at an increasing rate until the equipment was totally destroyed by the October 1960 fire. Within the record time of less than two weeks, replacement equipment provided by the IBM Corporation was installed in the basement of the Peeples-Newman Building in downtown Vicksburg and the computer facility was back in full operation.

23. It soon became apparent that the installed equipment was no longer capable of meeting the increased work load requirement. In November 1962, as the facility occupied new quarters in its present location, the IBM-650 was replaced with a card GE-225 which was approximately ten times as fast.

24. A flatbed Benson-Lehner X-Y Plotter, installed in July 1962, was used until decommissioned in January 1968 and machine plotting was thereafter confined to the Calcomp Incremental Plotter acquired in September 1965. The newer machine was a substantial improvement in that it provided annotation, special characters, etc., needed for automation of the drafting of plates for WES reports.

25. In October 1966, the growing work load justified addition of six low-density tape drives to the computer, which aided in the processing of business applications. Floating-point hardware was installed in March 1967, and this speeded processing time by a factor of 3.5 to 1 on the average.

26. As the Computer Branch grew in strength over the years, its staff of 24 personnel was divided in November 1966 into two sections: the Math and Analysis Section under J. F. Smith, and the Program and Operations Section under A. L. Gilmore.

27. By calendar year 1968 the work requirement for ordinary problems had so increased that a 23 hour per day, 7 day per week operating schedule was necessary. In addition, extra-large scientific problems that exceed the capacity of the local machine are being processed on large computers at other locations--the CDC 3800 of ESSA at Boulder, Colorado, and the Univac 1108 and SDS 930 of NASA at Slidell, Louisiana. A data-transmission terminal was installed in January 1968 to send and receive data off-line from the Univac 1108 in Slidell. Experience in time-sharing is also being obtained through the use of four Model 33 teletype terminals tied to a CEIR GE-265 computer in the Washington, D. C., area over a leased telephone line.

28. A GE-420 system is now being installed at WES, with GE-115 computers in three of the LMVD districts and Datanet interconnections, in order to accommodate

WES and LMVD needs for the period FY 69-72--or until the Corps Regional Center complex is formally implemented in the Vicksburg area some three years hence.

Instrumentation Branch

29. Perhaps no other technology in the past two decades has grown so dramatically in scope and complexity as has the electronics industry. With the rapid succession of new developments in this field, both the requirements and the capabilities of using organizations (such as WES) for more sophisticated measurement, control, and recording have grown accordingly.

30. The ordinary devices associated with hydraulic measurements have been with WES from the outset--point and hook gages, manometers, piezometers, etc., applied to the slowly changing physical quantities of interest. A small mechanical shops activity, under R. A. Ford, constructed tide-control apparatus and other electromechanical equipment for model studies then under way. There were no instruments nor commercial suppliers such as are commonplace today.

31. One of the first developments of consequence took place in 1938 when J. M. Caldwell began planning for devices to meet high-frequency requirements for the Station's first wave tank. This involved pressure cells and wave-height measuring devices and a suitable recording means. At about this time Eugene H. Woodman (present Chief of the Instrumentation Branch) was assigned to assist with wave tank construction and instrumentation--which resulted in design of a wave plunger incorporating PIV speed control and adoption of the stepped-resistor wave rod concept.

32. Shortly before the war the matter of instrumentation and mechanisms was indirectly recognized by establishing Experiment Station No. 4 in the Hydraulics Division, with Mr. Woodman in charge, to deal principally with special mechanisms on models such as the San Juan breakwater location, the surge and water-hammer characteristics of Power Tunnel No. 1, Fort Peck Dam, the Pump Suction Chamber of Dry Dock No. 4, Puget Sound Navy Yard, and others. Walter Slay, Robert Hudson, Thomas Spinks, and Alva Brothers were initially assigned to this group, which was subsequently augmented by Francis Hanes, William Crawford, C. E. Tompkins, and others. Work was assigned from the Soils Division (seepage analogy bridge, etc.) as well as the Hydraulics Division and during World War II measurements were made for many airfield pavement design studies--involving the development of pavement deflection gages and the improvement of a WES earth pressure cell utilizing strain gages as developed by Ford and Osterberg. During this period the group was reorganized to include R. A. Ford and his technical assistants and was redesignated the Electrical and Mechanical Section of the Hydrodynamics Branch, Hydraulics Division. One of the next major projects involved the specification and procurement of instruments for the Mississippi Basin Model.

33. In 1946, the Central Concrete Laboratory of the Corps was moved from

Mt. Vernon, New York, to WES and called upon the Electrical and Mechanical Section for the design and construction of a number of specialized mechanisms. By 1947, it was apparent that this Section was performing services for all WES technical elements and it was accordingly withdrawn from the Hydraulics Division, renamed the Instrumentation Branch, and operated as a separate staff element until incorporated into the Technical Services Division in 1949.

34. As WES became concerned with nuclear weapons effects testing, special equipment was required for the high-speed dynamic measurements involved. Francis Hanes returned from the Louisville District in 1956 to aid in this program and to continue his work as project leader and Corps consultant on the ES Project, "Development of Equipment for the Telemetering of Hydrologic Data." In this latter project, equipment for several complete networks has been designed, fabricated, and installed.

35. In the past few years many WES programs have become dependent on specialized instrumentation talent and equipment for their ultimate success. Facilities have been added for data reduction, high-speed analog-to-digital conversion, analog computer operation, and wave and spectrum analysis. Selection, writing of technical specifications, and procurement of many thousand dollars worth of complex equipment each year has become a major responsibility. Field measurements and installation of instruments in prototype structures require more personnel than before.

36. The Branch has grown from an earlier strength of 25 or so to a current strength of 65, and contains three mutually supporting sections: Dynamics, under Francis P. Hanes; Measurements and Testing, under Leiland M. Duke; and Construction and Maintenance, under William H. Crawford. As work requirements have grown and diversified, so also have the complexity of operations and the staff capabilities needed to meet them.

Appendix XI

CONSTRUCTION SERVICES DIVISION

Introduction

1. During the formative years of the WES there was no construction unit as such. Any personnel engaged in the supervision of construction work were borrowed from the Vicksburg District and other agencies for specific jobs on a short-time loan basis. Some of these temporary pioneer employees remained 35 years or over and were instrumental in the development of what is now known as the Construction Services Division. In addition to supervisory personnel, the initial work force of construction personnel consisted of approximately twelve laborers, a one-man machine shop, and a two-man carpenter shop. Hiring and firing was on a day-to-day basis, contingent upon the work load. Templates required for model construction were plotted by Hydraulics Division personnel and cut by construction workers. Equipment for model construction consisted of a half dozen pointed shovels, several mattocks, two mauls, and several wheelbarrows.

2. During the early 1930's, a warehouse was built which housed the sheet metal shop. A carpenter shop was erected at a slightly later date.

3. After a time interval of one to two years, construction requirements increased, and the first organized construction support group was formed under Horace T. Long. The labor force had increased to nearly 300. Six surveymen and craftsmen as required had been added to the work force. The biggest construction project at this point (1934) was the building of the Mississippi River model (referred to as "94"). Six transitmen, 50-100 laborers, mules, and slips were used to construct this model.

4. As activities expanded, a need for a shops building to house the crafts became apparent. Accordingly, such a building was constructed during 1939 and contained all crafts under one roof and continued in this location until the new, modern shops building was constructed and occupied in November 1967.

5. After construction of the Mississippi River model, there was a fairly even flow of lesser model construction. In November 1940, numerous Reserve and National Guard Officers were called to active duty. Among these in the key category of Construction personnel were Mr. C. R. Warndof, Chief of the Division, and Mr. J. G. Schaffer. During the war years, Mr. G. W. Vinzant assumed Mr. Warndof's duties and continued in this position even after Mr. Warndof's return from active duty. No major breakthrough in construction occurred until the period 1940-46 at which time the war effort brought about the construction of simulated rice paddies, studies in trafficability, and an increased volume of work in soils studies.

6. From the period 1946 to date, the work of this Division, excluding the Mississippi Basin model, has steadily increased in scope and volume. Two new

technical divisions were added which increased the requirements for support from the Construction Services Division.

Organization and Major Changes in Organization

7. In 1937, the Construction Services elements of the WES were known as the Operations Section. This Section was composed of the Construction Section, Mechanical Section, Field Administration Section, Carpenter Shop, Watchman, and Labor Pool. In 1941, the Laboratory Services Division was formed consisting of a Shops Section and General Construction Section. In the early part of 1946, the Division was reorganized and designated Operations Division. The Division at that time consisted of a Shops and Model Construction Branch, Supply Branch, Mississippi Basin Model Construction Branch (Clinton), and Safety Section.

8. In 1947, the Operations Division was composed of the Shops Branch, Construction Branch, Operations Branch (Clinton), Equipment Operations Branch, and Estimates and Records Section. The organization was the same in 1948, and in that year the Division reached the peak in personnel employment with approximately 770 employees.

9. The Division was reorganized in 1949. The Construction Branch was divided into two separate branches, the Construction Branch and the Model Construction Branch.

10. In 1951, the Division was reorganized and designated as the Construction Services Division, consisting of the Construction and Maintenance Branch and the Engineering Branch. Personnel strength during that year varied from 246 to 375 employees.

11. From 1951 to 1957 no major changes in organization took place. Personnel strength during those years averaged about 200 employees.

12. In 1957, the Division was again reorganized to include the Shops Branch, Engineering Branch, Construction and Maintenance Branch, and Construction and Maintenance Branch (Jackson Suboffice). From 1957 to 1963 there was no change in organization. Personnel strength during this period ranged from 189 to 285. In 1963, the Plant Section was withdrawn from the Engineering Branch and established as the Plant Branch. In this year also, the position of Assistant Division Chief was established.

13. Since 1963 there has been no reorganization of the Division except for the abolishment of the Assistant Division Chief position in 1967. Personnel strength from 1963 to 1967 averaged between 285 and 300 employees.

Engineering Branch

14. This branch was first created and known as the Estimates and Records

Section in 1947. In 1951, the Construction Services Engineering Branch was formed and consisted of the Plans and Specifications Section, Plant Section, Inspection Section, and Materials Testing Section. In 1952, the name was changed to Engineering Branch. The Engineering Branch was reorganized again in 1953 to consist of the Engineering Section and Plant Section. These two sections remained until 1963 when the Branch was reorganized into the Design and Specifications Section, Estimate and Inspection Section, and Plant Section. Later on in 1963 the Plant Section was established as a branch. The Engineering Branch has consisted of two sections, Design and Specifications Section and Estimate and Inspection Section since that date.

15. A major portion of personnel time in the Engineering Branch is devoted to consultation, design, and development of new and unique types of special purpose test equipment and facilities.

Shops Branch

16. During the middle 1930's the shops were separated both organizationally and geographically. Each shop had a foreman but there was no general foreman or branch chief. The shops were a part of what was then the Operations Division and were under the supervision of the chief of that division.

17. During the period from 1938 to 1941, the shops employed approximately 25 people and occupied a total area of approximately 4000 sq ft. The total area occupied by all the shops at that time was less than half the total area now occupied by the machine shop alone.

18. Increased demands and massive construction programs during and immediately following World War II created a tremendous rise in the number of employees in the shops. At peak periods from 1941 to 1946 several hundred people were working in the various shops. During this same period the plastic shop came into being.

19. After the war ended, the shops personnel was reduced back to its original strength and remained relatively stable with an average strength of between 35 to 45 until 1960. A rapid growth in work load resulted in an increase in personnel from 45 to 97 during the period 1960 to the present.

20. In 1967, the shops moved into a new building with a total area of 33,600 sq ft under one roof.

21. The early shops were small in size and personnel, had very few power or machine tools, and performed but a limited number of operations. Precision equipment was nonexistent, rendering highly complex, close tolerance work almost impossible.

22. The machine shop began with three second-hand lathes (which we still have, by the way), a small mechanical shaper, a band saw, and some hand tools. Today the machine shop has 14 lathes (ranging in size from 10-in. swing to 37-1/2-in. swing), one of which is capable of working to one ten-thousandth of an inch. The machine

shop also has milling machines, grinding and honing machines, numerous drill presses of various sizes, and a jig boring machine capable of locating and boring holes to within 25 millionths of an inch. The machine shop now produces such items as instruments and gages of all sorts, model rocket engines that produce 500 and 1000 lb of thrust, triaxial and torsional shear machines for soils testing, tide-control mechanisms, wave machines, and automatic valves for hydraulics research, and myriad other items as necessary.

23. The welding shop began with a few oxy-acetylene torches and an anvil with the capability of welding steel only. Today, the welding shop has the very latest in welding equipment with the capability of welding all types of steel, aluminum, copper, stainless steel, and exotic materials such as titanium. The equipment now used by the welding shop includes carbon-electrode arc welders, gas shielded-arc welders, and an environmentally controlled welding chamber. The welding shop works in conjunction with the machine shop in the production of the items mentioned above.

24. The early electric shop performed standard installation and maintenance work on buildings, model shelters, and relatively low-voltage transmission lines. The electricians today deal with primary transmission lines of 13,800 volts, perform the installation of complex circuitry for tide-control devices and remote-control systems, and in addition perform repair and rewinding of motors up to 200 hp and transformers up to 750 kva.

25. The temperature control shop is an outgrowth of the electric shop and came into existence around 1948 when project requirements dictated the use of environmentally controlled areas. Today the temperature control shop works with heating and ventilating systems of all types and sizes, cold storage and cold room equipment, freezers, dehumidifiers, and air-conditioning units up to 250 tons.

26. The sheet metal shop began with one 8-ft brake, a hand roll, a power nibbler, and a few hand tools. The shop now has almost all the tools and equipment necessary for a first-class sheet metal shop. The type of work has evolved from some model work and primarily standard sheet metal construction to almost exclusively model construction. The shop produces extremely complex structures, crests, piers, transitions, weirs, gates, electrical and electronic control and wiring boxes, and special tanks of all sizes and shapes.

27. The nature of the work performed by the carpenter shop has remained relatively unchanged through the years. Improvements in methods, techniques, and most certainly equipment have increased the capabilities of the shop. The carpenter shop now is equipped with power saws of all types, both automatic and manual, power drills, planers, shapers, routers, joiners, and sanders. The carpenter shop now employs cabinetmakers of the highest caliber, capable of producing items of aesthetic as well as functional value.

28. The early pipe shop was located in what is now the expendable property warehouse and performed standard plumbing work on water, gas, and sewer lines and supply and return lines to hydraulic models. Today the pipe shop still performs the standard utility and model piping, but in addition to this they also install and maintain high pressure steam systems, hydraulic and pneumatic control and power systems, and piping systems with pressures to 3000 psi for handling liquid oxygen, nitrogen, and hydrazine.

29. The first paint shop was responsible for painting structures and buildings both inside and out, and signs to a limited extent using oil base paints which they mixed themselves and applied with a brush. The paint shop still performs these duties but they now use latex, acrylic, and epoxy paints and has the latest in spray equipment both of the air and airless type. It also provides sandblasting, furniture refinishing, sheetrock finishing, and signs of all types from standard lettering to gold leaf.

30. The plastic shop is an offspring of the carpenter shop and came into being during the early 1940's when project requirements demanded that some models be constructed of a material that was transparent. The material chosen was an acrylic plastic called plexiglass, and since this material was worked much in the same manner as wood, carpenters were selected for the work. The people employed in the plastic shop have always been highly skilled patternmakers and cabinetmakers because the work produced must adhere to rigid requirements and close tolerances. In addition to working with plexiglass the plastic shop now works with fiber glass and all types of plastic products, such as epoxy and pōlyester resins, silicones, urethanes, fluorocarbons, and vinyls. The shop now constructs extremely complicated model structures, fiber glass molds of all types, special pipes and tubing, and numerous flotation devices.

31. The Shops Branch, which began not as a branch but essentially as a shade tree operation with limited capabilities, has developed and matured into an organization of unlimited potential. The Shops Branch is now capable of constructing almost any type of structure, machine, instrument, gage, or mechanism as needed in the research program here at WES. The Shops Branch also provides assistance in the procurement of materials and equipment as well as advisory and consulting services for special projects. The Branch is limited in its capabilities only by the lack of certain tools and equipment necessary to perform highly specialized work. With the procurement of the needed tools and equipment, the capabilities of the Shops Branch should be truly limitless.

Construction and Maintenance Branch

32. The duties of the Construction and Maintenance Branch are defined in the functions of the three sections listed below:

Model Construction Section

33. The Model Construction Section constructs and revises all models. Types of models are fixed bed, movable bed, tidal, salinity, structural, wave action, and locks and dam. They vary in size from very small models to large ones with a total cost of $200,000 or more. The funds used in this section are reimbursed by the contracting agencies. In the early years, generally only one model was constructed at a time; now six can be constructed concurrently.

General Construction Section

34. The General Construction Section performs all necessary support work for the various technical divisions. Such work consists of construction of test strips for various types of landing mat, vehicle test strips, and other types of tests connected with advanced airfield construction. This section maintains the Station grounds, roads, streets, and drainage; it erects steel structures, including foundations, constructs sumps (water reservoirs for hydraulic models), and provides a work force incidental to the operation of the Station.

Equipment Section

35. This section maintains and operates over 400 pieces of equipment including test vehicles of all types, trucks, cranes, dozers, front end loaders, graders, and stationary plant facilities, such as asphalt and materials processing plants. The Equipment Section delivers materials to field parties throughout the United States as well as furnishing equipment operator support for special tests outside the Station confines.

Plant Branch

36. In 1951, the Plant Branch was first organized and known as the Plant Section. It remained the Plant Section until June 1963 when it was reorganized and designated as the Plant Branch.

37. The Branch is responsible for the Station's five-year Plant Replacement and Improvement Program, preparation and administration of the plant maintenance budget, military housing maintenance budget, comprehensive preventive maintenance program for mobile and fixed land plant and residences, and RDT&E special purpose equipment. The Branch writes specifications for purchase of engineer equipment and vehicles and for inspection of the equipment upon delivery, and is the requisitioning unit within the Division for tools, supplies, and materials.

Construction and Maintenance Branch, Jackson Installation

38. In 1942, MG Eugene Reybold directed Mr. G. H. Matthes, Director of the WES, to conduct an investigation of the practicability of constructing a model of the entire Mississippi River and its tributaries, together with all of the reservoirs and watershed.

39. The Chief of Engineers, in December 1942, ordered the South Atlantic Division to start building a prisoner-of-war (POW) camp at the present site of the model located nine miles southwest of Jackson and three miles southeast of Clinton. This site was chosen primarily because this property topographically fitted the model requirements more closely than other sites investigated.

40. The South Atlantic Division began construction of the POW camp early in 1943, and in August 1943 German POW's were brought to the site to provide labor for construction of the model. The POW's worked on the project until May 1946. The construction of the model, including its verification, was essentially completed in FY 1967. The Arkansas River portion of the model has been completely rehabilitated and revised to reflect the conditions that will exist after the Arkansas River project is completed. This revision was begun in March 1965 and completed in FY 1968.

41. The work accomplished by the POW's under the supervision of CPT H. G. Dewey, Jr., and Mr. K. A. Dupes consisted primarily of moving dirt (approximately 1,000,000 yd, the major portion of which was accomplished after departure of the POW's) to mold the 210-acre site to reproduce the correct topography of the Mississippi River Basin. Installation of about 85,000 lin ft of storm sewer, which was also primarily accomplished after departure of the POW's, and drainage work on the model site were done primarily by hand labor.

42. Civilian personnel under the direction of Messrs. H. G. Dewey, Jr., J. J. Franco, and K. A. Dupes, design engineers, and Mr. A. G. Davis, construction engineer, took over the actual construction of the model after the model site had been prepared by the POW's. Later Mr. Dewey and Mr. Davis left the WES and the late Mr. H. C. McGee and the late Mr. R. E. Hinton assumed responsibility for the design and construction, respectively, of the model. Mr. T. A. Leggett succeeded Mr. R. E. Hinton, who died in 1963, as construction superintendent.

43. The original method of construction followed the normal model construction techniques--construction on the ground in place to cross-section templates placed from 1-1/2 to 2 ft apart. Later, because the expanding clay in the model area was causing excessive heaving of the model, the method of construction was changed. Mr. K. A. Dupes, under the supervision of Mr. H. C. McGee (both now deceased), and with assistance from the construction forces under Mr. R. E. Hinton, developed the contour method of construction which was used in constructing the remainder of the model. Under this new method, model blocks, varying in size up to 150 sq ft, were molded on an assembly line method, transported to the model site, and put in position on poured-in-place concrete piles. One-quarter-inch strips of 22-gauge metal, bent to conform to full-scale contours of the model blocks were inserted in slots cut in the end of 1/8-in. metal rods which were precut to the particular contour elevation and installed along the alignment of the contour. This provided metal contours for molding the concrete. After a seven-day cure the side forms were removed; and the blocks were carried by truck to the model site and placed on 8-in. concrete piles

with bell bottoms that had been poured in place to a depth of 10 ft, which is generally below the expansive clay and the moisture content is more or less stable. A screw jack was imbedded in the concrete block during construction and metal bearing plates were placed on top of the piles to receive the screw jacks. When the blocks are set to the correct grade there is a void of about 1 ft. This prevents the upper layer of soil from pushing the blocks upward when it expands.

44. The cost of construction and design of the Mississippi Basin model was $11,030,998, and the cost of maintenance was $1,718,287 as of 1 January 1968.

45. In FY 1964, a public access program was added to the Mississippi Basin model, including the construction of an assembly building, addition to a tower, visual aids, signs, walks, and viewing platforms. This work was essentially completed in 1967 at a cost of $60,000 and a cost of $22,000 for annual maintenance.

46. The Construction and Maintenance Branch, Jackson Installation, was organized in 1943, primarily to construct the Mississippi Basin model and lend support to the Concrete Division. Approximately 200 people were assigned for construction of the Mississippi Basin model. This Branch has now been reduced to 31 people. The phasing out of the construction of the Mississippi Basin model brought about a drastic reduction of manpower in this Branch. The principal duties of the Branch now are to lend continuing support to the Concrete Division and make revisions and maintain the intricate electronic equipment needed for the operation of the Mississippi Basin model, and to provide maintenance as required on the reservation.

Experiment Station Lake

47. Included in the reservation area is what is referred to as the WES lake. This lake was developed primarily to furnish water as required to early models. Throughout the years, from 1929 to 1966, silt deposits accumulated in the lake to such a degree that it became necessary to perform dredging operations to preserve this lake. Approximately 278,000 cu yd of silt were removed in 1966.

Housing

48. During the period 1940-1945, the need for housing in the Vicksburg area became extremely critical. To alleviate this critical shortage and to provide additional facilities for military personnel who were being assigned to the Waterways Experiment Station, Vicksburg District, and Mississippi River Commission, returning servicemen, and other engineer and scientific personnel, 11 new houses were constructed and 1 existing house on the reservation was renovated. In addition to this, 7 apartment buildings containing 37 units were constructed in 1946. One of the residences in the vicinity of the Headquarters Building was demolished. The remaining 12 houses are still occupied by military personnel of the Vicksburg District,

Waterways Experiment Station, and Mississippi River Commission. As the shortage of housing became less acute, the apartment complex was sold to private interests in 1955.

Dollar Volume of Work

49. About 1946, the plant funds allocated WES were $400,000 to $500,000 per year and probably less in earlier years. This figure has steadily increased to the present program of $2,700,000.

Grade Structure

50. The position of Division Chief was originally established at GS-13 level and was upgraded to GS-14 in 1953. There has been no change since that time. The Chief, Engineering Branch position was established in 1951 as GS-11. With added functions and responsibilities, it progressed upward to its present level (GS-13) in 1960. There has been no change in the grade of the position of Chief, Construction and Maintenance Branch since it was established at GS-12 in 1951. The Chief, Shops Branch position was changed from wage board to classified, GS-12, in 1963. In 1968 it was raised to GS-13. The Plant Branch was organized in 1963 with the position of Chief, Plant Branch, established at Grade GS-11. It has since been upgraded to GS-12. The grade levels of the clerical force are basically the same as they were 20 years ago.

51. The grade structure and pay rate of wage board employees have not kept pace with industry through the years and except for across-the-board "cost of living increases," there has been little improvement in the wages of unclassified employees.

Key Personnel Responsible for Significant Results

52. This Division has had four division chiefs to date: Horace T. Long, C. R. Warndof, G. W. Vinzant, and J. G. Schaffer. Other key personnel throughout the years have been R. A. Ford, Barney Havis, W. C. Hunt, "Goat" Smith, Will Davis, Frank Musil, R. N. Leggett, T. A. Leggett, R. E. Hinton, Al Davis, John Barnett, R. T. Garner, J. C. Allen, G. H. Bragg, J. M. Peterson, G. T. Easley, C. L. Rone, J. E. Ballesteros, A. L. Sullivan, Sr., P. W. Tompkins, J. P. Wislocki, R. Findley, T. Findley, Teddy Schmitt, G. Schuman, E. Trevillion, John Loviza, J. H. Lauderdale, Willie Rodgers, C. A. Davidson, Robert Bailess, C. Montague, R. A. Armstrong, J. Brogdon, J. P. Pace, Henry Smith, J. M. Hebler, W. R. Leist, E. J. Cronin, M. R. Hale, J. F. Elliott, Kenneth P. Eikert, and G. P. Rae.

Laboratory and Office Space

53. In 1930-31, the first office-laboratory building containing approximately 20,000 sq ft was constructed. From this original beginning, several small administrative office and storage buildings were constructed in 1934, increasing the total to approximately 26,000 sq ft. During the period 1935 through 1945, a considerable number of buildings were added--some of them temporary, which have since been removed. Of the buildings constructed during this period, there remains approximately 65,000 sq ft of area. Some of the larger buildings constructed were the old shops buildings (1940), warehouse building (1939), Supply and Procurement Office building (1939), and a large model shelter (1942) which now houses the Niagara Falls model. The period from 1945 through 1960 saw a rapid expansion in facilities, particularly model shelters. Approximately 620,000 sq ft of shelters was constructed in 1947-48, several from airplane hangars obtained from war surplus. It was during 1948 that an office building containing approximately 6500 sq ft was constructed as headquarters for the Hydraulics Division. An additional 17,000 sq ft of office and administrative function space was also constructed, as well as approximately 31,000 sq ft of warehouse and storage space.

54. The early 1960's saw the beginning of construction for most of the present office buildings. The Headquarters Building containing approximately 44,000 sq ft was completed in 1963. An extension to the first office building (constructed in 1931) was completed in 1962, and another addition in 1966. The Reproduction and Reports Branch building was completed in 1966, the Mobility and Environmental Division building in 1965, Nuclear Weapons Effects Division building in 1965, Soil Dynamics Test facility in 1962, and the Blast Load Generator facility in 1963. Several large model shelters were constructed during this period; the largest one containing approximately 163,000 sq ft was completed in 1965. In 1966 the new mechanical shops building containing approximately 33,600 sq ft was completed. Presently under construction is the new Concrete Division laboratory and office building with completion scheduled early in 1969.

55. The WES has expanded until it presently has approximately 1,500,000 sq ft of office, laboratory, test facilities, and storage space; approximately 1,200,000 sq ft of this is hydraulic model shelters and similar test areas, 50,000 sq ft of storage, and 225,000 sq ft of office space.

Monetary Savings

56. This Division is continuously in search of cheaper and better ways of performing its functions. The wooden structures of the 1930's and early 1940's were replaced by surplus airplane hangars in the late 1940's and finally by galvanized iron and aluminum skins over structural steel frame starting in the 1950's. The cost of

the wood shelters was approximately $8 per sq ft and the cost of the latest galvanized iron over steel trusses and columns, $1.50 per sq ft.

Physical Growth and Changes in WES

57. The original reservation (September 1930) consisted of 147 acres. In 1934 an additional 100 acres was purchased; 1944, 45 acres; 1946, 47 acres; and 1947, 90 acres. In 1955 approximately 16 acres was disposed of, and in 1965 to 1967 an additional 180 acres was purchased--total approximately 595 acres. The attached map (fig. XI-1) shows the various additions and the dates acquired.

Technical Society Participation

58. Seventy-five percent of the engineers in the Construction Services Division are registered professional engineers (1967) and belong to various professional societies. One engineer is President-elect of the Mississippi Society of Professional Engineers, Vicksburg Chapter.

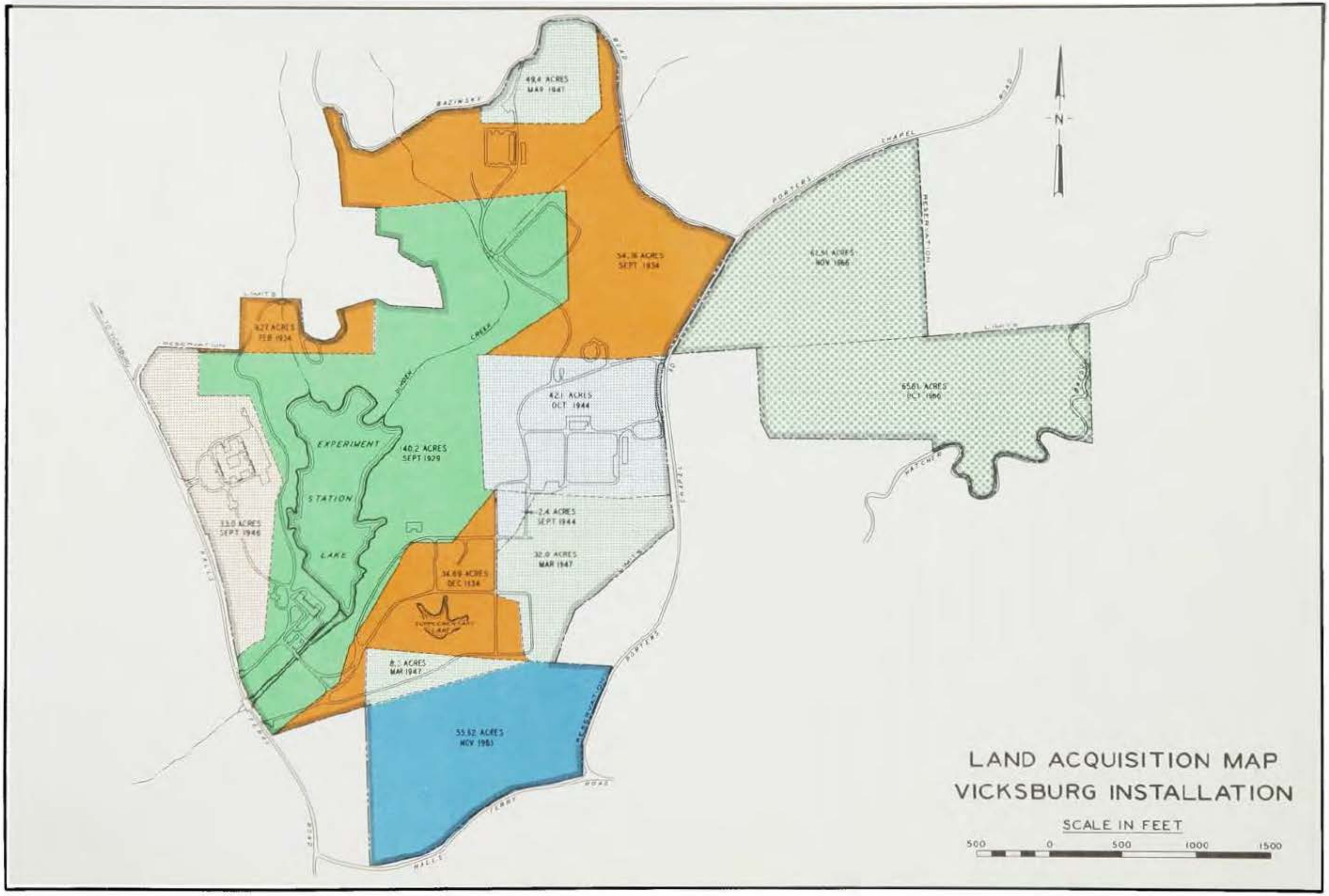
49.4 ACRES
BAZINSKY
EXPERIMENT
STATION
LAKE
140.2 ACRES
SEPT 1929
42.1 ACRES
OCT 1944
2.4 ACRES
SEPT 1944
32.0 ACRES
MAR 1947
33.0 ACRES
SEPT 1946
CREEK
PORTERS
CHAPEL
ROAD
RESERVATION
LIMITS
HALLS
FERRY
N
LAND ACQUISITION MAP
VICKSBURG INSTALLATION
SCALE IN FEET
500
0
500
1000
1500

Fig. XII-1

Appendix XII

OFFICE OF TECHNICAL PROGRAMS AND PLANS

1. General Order No. 4 of the Waterways Experiment Station created the Office of Technical Programs and Plans, effective 12 July 1963, under the Technical Director to provide improved technical control and coordination of WES work at the Executive Office level.

2. F. R. Brown was named as Acting Chief of the Office of Technical Programs and Plans in addition to his designation as Assistant Chief of the Nuclear Weapons Effects Division. Additional qualified personnel were sought to strengthen the organization and provide the desired scientific and technical direction, guidance, and coordination of the various programs of WES.

3. Work was carried forward in a limited way until W. R. Martin was appointed by Special Order No. 34, dated 22 October 1963, as Chief, Management Branch, Office of the Comptroller with a dual assignment in the Office of Technical Programs and Plans. Since neither Mr. Brown nor Mr. Martin could accomplish the functions desired while in a dual assignment, it was decided to make a Corps-wide recruitment for the position of Chief and to assign Mr. Martin full-time to the Office of Technical Programs and Plans. Since the recruitment effort did not produce any qualified candidates, Mr. Brown, then Chief of the Nuclear Weapons Effects Division, was transferred to the Executive Office on 14 December 1964 and assigned duties as Assistant Technical Director and Chief of the Office of Technical Programs and Plans. Thus, the organization was staffed and fully functional at the beginning of 1965 with Messrs. Brown, Martin, McCarley, and a secretary. J. C. Oldham, engineer, joined the organization in March 1966. At present the organization consists of three engineers, one program officer, and a secretary.

4. The Office of Technical Programs and Plans assists the Technical Director in the management and coordination of technical programs, particularly those wherein projects involve more than one technical division. This office also provides a single information and contact source for agencies for whom work is being conducted; sufficient background information is readily available to provide on-the-spot information. Input data are collected on all phases of WES activities and placed in table, chart, and slide form for the information and guidance of the Director, the Deputy Director, and the Technical Director. Statements of work proposed for assignment to WES are reviewed; technical proposals, papers, and reports are evaluated; reports for higher authority requiring input from the various technical divisions are coordinated and prepared. Careful attention is given to the detection of critical areas requiring action before they become problems. Files of commitments are maintained to permit scheduling of facilities and technical effort to best advantage. Work programs are balanced against personnel requirements; statements of investigational work are secured in advance for work load planning purposes. A Long-Range Plan for WES is

prepared and updated every two years. Numerous other special duties are performed as the need arises or as requested by the Executive Office.

5. During the past year considerable effort has been expended to develop a computerized management system designed to provide more and better up-to-date information on work scheduling and costs, which will in turn be used for guidance in management decisions. This work has been accomplished in cooperation with all divisions of WES.

Appendix XIII

OFFICE OF ADMINISTRATIVE SERVICES

Organizational Growth

1. The Office of Administrative Services had its beginning in 1930 when James H. Moore came to WES as a stenographer. At that time the need for administrative support to the technical personnel was very small, because all administrative services were being performed by the MRC. Moore's primary duty was the preparing of requisitions and time rolls which were then forwarded to the MRC for processing. The organization grew slowly for the next few years with the addition of several more employees under Moore's supervision as Chief Clerk. In 1932, a telephone switchboard was added and Mrs. Lucille Nettles was hired as the first operator. In 1936, Moore was appointed head of the Administration Section which was made up of six subsections. These subsections were: (a) file and library, headed by Claude C. Lee, assistant clerk; (b) stenographic work, performed by junior clerks Earl H. Teeter and M. B. Jacobsen and stenographer Mary K. Donald; (c) telephone switchboard operated by Ivy V. Hanna; (d) messenger service; (e) instructor's assistant, W. C. Koerper; (f) transportation, with chauffeurs Jimmy Duncan, J. Jackson, C. Gary, and R. Smith.

2. By 1941, the Administration Section had been reorganized as the Administration Division under Moore, and consisted of three sections: Administration, Library, and Supply and Property. The scope of the services provided had been expanded in that the supply and property responsibilities for WES had been added under S. W. Watson, storekeeper. By 1943, two additional sections had been added. The first was the Cost Section with H. L. Calvin as principal clerk and the Personnel Section headed by Luther C. Marsalis, Jr., as senior clerk. Other organizational changes within the Administration Division at that time included designation of secretarial services under Alva F. James and library under Katharine McDiarmid as assistant librarian. During this period George W. Metz, Jr., was appointed as head of the Files, Mailing, and Physical Data Section. These changes indicated that WES organizations were assuming more administrative responsibility, resulting in a decline in MRC control and signaling the eventual transfer from MRC to OCE supervision several years later.

3. After the beginning of World War II, the Administration Division remained fairly stable organizationally, but experienced numerous personnel changes as employees entered into active duty in the armed services. It was during this period that Ernest Faulkner became head of the Cost Section; H. L. Calvin moved to the Personnel Section to replace Marsalis who left for active duty; and V. C. "Post" Farrior was placed in charge of Files, Mailing, and Physical Data Section.

4. In 1946, Moore became an Administrative Assistant in the Special Assignments

Branch directly under the Executive Office, and Earl H. Teeter was promoted to head the newly designated Office Service Branch, replacing the Administration Division. Although the name was changed, the services provided by the Office Service Branch remained much the same. With the placement of WES directly under OCE in 1949, the Personnel Section and the Procurement and Property Section were established as separate branches. At this time Moore returned as head of the Office Service Branch, which consisted of the General Service Section headed by George Metz, Jr. This one section included the records administrator, telephone operator, all clerk-stenographers, mail and file clerks, and the messenger service.

5. It is important to note that at this time at the WES Clinton Suboffice there was an Administrative Branch headed by James A. Harris, which included a Personnel Section, under M. M. Aden; a Cost Section, under E. B. Yarbro; an Office Service Section, under W. M. Pace; and a Supply Section, under L. L. Spencer. Later, the existing Security Section, under W. P. Taylor, was placed under the Administrative Branch. This Branch provided the Clinton Suboffice with services similar to those provided by the Office Service Branch for the Vicksburg Installation, but at that time was not connected with its Vicksburg counterpart. As the personnel strength of the Suboffice declined, the duties of these sections were transferred to Vicksburg and only the Security Section remained, it being placed under the Office Service Branch.

6. A Travel Unit was organized in 1947 with Jack Garner as the Travel Clerk. D. P. Maggio was appointed as a Travel Clerk in late 1947 to replace Garner who transferred to Finance. Maggio also moved to Finance in 1948 and W. M. Pace transferred from the Suboffice to become Travel Clerk.

7. By this time, the General Service Section had organized its work under definite functions which were later to grow into major administrative programs at WES. V. C. Farrior was the records administrator working in the early records program, and R. N. Hennegan, methods examiner, was in charge of Forms Control.

8. The fire fighting and guard services in 1947 were in two separate sections under the Utilities and Security Branch. Bob Mobley was Chief of the Guard Section and the Fire Protection Section Chief's job was vacant. Also under the Utilities and Security Branch was the Transportation Section headed by R. B. Feibelman. The services provided by these three sections were subsequently placed under the Office Service Branch in 1948. In that same year, Joe Scott returned from military service and was placed in charge of the Transportation Section as the motor vehicle dispatcher. Bob Mobley was appointed head of the newly designated Security and Custodial Section, which included fire protection, guard services, and janitorial services.

9. In 1951, Moore transferred to the Fiscal Branch to supervise the Cost Section and Metz was appointed Chief, Office Service Branch, in a dual capacity as Chief, General Service Section. The Branch at that time consisted of only two

sections: the General Service Section, providing records, forms, mail and records, messenger, communications, correspondence, travel, and transportation services; and the Security and Custodial Section, providing guard, fire, and janitorial services. Katherine Ellis became Chief of the Travel Unit, and Pace moved to the position of Records Administrator when Farrior was called to active military duty. This organizational structure remained constant until 1954, except for a brief period in 1951 and 1952 when the Security Section was placed under the Construction Services Division.

10. In 1953, James Harris transferred from the Clinton Suboffice to the Vicksburg Installation as Chief of the Office Service Branch. Metz remained Chief, General Service Section, and the Security and Custodial Section was brought back under Office Service Branch with Bob Mobley again as its head, after his return from the Korean War.

11. With the steady growth of the Station, the work of the Mail and Records Section had expanded to the point that in 1954 it was made a separate section under the Office Service Branch, and was responsible for the mail function, central files, records management, and messenger service. Metz remained as chief of the section. William Pace was promoted to Chief, General Service Section. In 1955, a lengthy illness forced Metz to step down from the position of section chief and L. L. Spencer transferred from Construction Services Division as Chief, Mail and Records Section. In 1959, he retired and Farrior moved up to replace him. Mina Hall, who was a travel clerk, was promoted to Chief, Travel Unit, in 1960 when Katherine Ellis transferred to the Construction Services Division. In 1961, the Forms Management Section was formed and Pace was appointed its chief. J. S. Taylor, Jr., became head of the General Service Section.

12. A major reorganization of the Office Service Branch was effected in 1963 to bring it into line with other Corps of Engineers elements, and to better define the Branch's functions and responsibilities. The new designation was Office of Administrative Services; the four sections were elevated to branch level, and the units redesignated sections. Fred Shields was Chief, Messenger Section, and Clarence Connor was promoted from janitor to Chief, Custodial Section.

13. Harris retired in December 1965 and Taylor was moved to the chief's job. The following December brought substantial changes in the personnel staff. Farrior retired as Records Management Officer, Edith Rollins and Zera (Walters) Ramsey retired from Mail and Records, and Eva B. Love died of a heart attack. Dot Atkinson was promoted to Records Management Officer, and Lois Criner became head of Mail and Records. Mildred Glenn transferred from the telephone switchboard to assume the duties previously performed by Eva Love.

Significant Activities and Events

14. The Records Management Program and the Forms Management Program have

played an increasing important role in the last few years in improving the efficiency of the Station's paper work. This is the result of Department of the Army emphasis on the reduction of records produced and maintained, and on finding the least expensive way of handling the flow of paper. The Records Program at WES evolved from the part-time efforts of several mail and file clerks in the early 1940's to full-time duties for a Records Management Officer and a file clerk. Significant milestones in the program have been the establishment of a records holding area in 1945, conversion to the Army functional files system in 1961, and decentralization of the Station's record files in 1965.

15. The Forms Management Program at WES has likewise experienced a steady growth, and now enjoys a good reputation known throughout the Corps of Engineers. This is due in part to the many WES forms now in use in other Corps of Engineers activities. Many of these forms retain the WES form number, and are requisitioned from WES. Also, in 1962 OCE gave WES the task of standardizing the cement and pozzolan testing forms used throughout the Corps, resulting in further recognition of the WES Forms Program.

16. From October 1960, the date of the fire, through June 1963, when the new Headquarters Building was occupied, Office Service Branch was busy with a multitude of additional jobs in effecting recovery from the disaster, and in planning and working toward occupancy of the new building. On the day of the fire, action was begun to relocate offices which had been burned out, and to obtain needed furniture and equipment to reestablish operations. The relocation of the Reproduction and Reports Branch to the Park Building necessitated the establishment of a courier service between that office and WES. Howard Jones transferred from the LMVD as a chauffeur and was assigned the courier job.

17. Many employees lost personal property in the fire, which resulted in the filing of a substantial number of claims against the Government. Although the Office Service Branch had been assigned claims and investigating responsibilities several years earlier, in lieu of the Station having an Office of Counsel, the Branch had never had as many and as unique a group of claims as were filed at that time. The Office of Administrative Services has continued to be responsible for processing all claims, except those that are contractual in nature which are handled by the LMVD Office of Counsel.

18. The fire in 1960 and the Cuban missile crisis in 1962 emphasized the need for the services provided by the Security and Custodial Section. Although the WES firemen were not able to save the Headquarters Building, because of the nature of the fire and the rapidity with which it spread, their immediate availability did prevent the loss of the Soils Laboratory and some valuable records. The Cuban missile crisis was an exercise in increased physical security. Since there were not enough personnel in the Security and Custodial Section to man all established guard posts, employees in other sections were placed on overtime to guard these additional posts after

normal duty hours. Since that time, additional emphasis has been placed on physical security planning for emergencies, and subjects in the field of security have been added to the training program for the Security Sections.

19. The Travel Branch has assumed a progressively heavier work load each year as the requirement for WES employees to make official trips to accomplish the Station's mission steadily increases. The greatest percentage of increase is in the area of overseas travel, since WES has taken on more projects necessitating visits by project personnel to Europe, South America, and the Far East. The importance of this organization is recognized in its evolution from unit status to branch level.

20. In 1966, when local ambulance services were discontinued, the Office of Administrative Services converted a carryall into an ambulance. This vehicle is operated and maintained by the firemen, and has proved to be a very valuable complement to the services provided by the Health Service Unit.

21. Communication services have been improved and expanded over the years as the need for them has increased. A new dual-position 608 PBX telephone switchboard was installed in 1963 as a replacement for the original switchboard installed in 1932. The first mobile radios were installed in WES automobiles and trucks in 1963. The radio network now includes three frequency channels and approximately 27 mobile units, and provides immediate communication to WES mobile units in the Jackson area and at the Big Black Test Site.

22. WES was not involved with the handling and storage of classified information until after the beginning of World War II, and then only in limited quantities. After the end of the war, there were an increasing number of projects requiring production, storage, transmission, and destruction of classified documents. The Security Officer's job at this time was established as an additional duty for W. L. Bache, Jr., Executive Assistant, but as the volume of material increased, this responsibility was later transferred to Harris. The duties of this job also included the periodic changing of combinations on classified security containers. The Security Officer's job remains a major function of the Office of Administrative Services.

23. The Transportation Section has always been a center for great activity because of the large demand for official transportation occasioned by the Station's remoteness from commercial transportation facilities. Through the years it has been necessary to use chauffeur-driven vehicles to transport WES travelers to and from the airport and railroad station in Jackson. The trips to Jackson had become increasingly easier and shorter as the highway had been improved over the years. However, in 1963 the new Jackson airport in Rankin County was opened, adding approximately 40 miles to the round trip between Vicksburg and the air terminal.

24. Cafeteria facilities at WES were nonexistent in the early 1940's. However, there was a concession area located across the street from the Headquarters Building

which was operated by an employees' organization known as the Employees Cooperative Association and managed by Mrs. F. C. Froehlig. By 1946, a cafeteria had been constructed and a contract awarded to Mrs. Annie Mae Foster for its operation with the Office Service Branch responsible for generally monitoring the operation of the cafeteria. Later, as the demand for more dining facilities increased, the cafeteria was relocated to the Headquarters Building, and a small concession constructed near Hangar No. 1, both of which have been operated continuously by Mrs. Foster.

Appendix XIV

SUPPLY AND PROCUREMENT OFFICE

1. Supply activity at the WES began in the summer of 1933 when S. W. (Sam) Watson, assisted by Tyler Bayne, opened a small one-room toolhouse as a part of the Administrative Unit of the Operations Division (now Construction Services Division). As first constituted, the Supply primary mission was the storing, issuing, and repairing of commonly used tools and equipment for use by the entire Station, although primarily for the construction forces. Gradually, the function expanded to include keeping on hand a small supply of nails, nuts, bolts, etc., for general use.

2. With the advent of construction "on the hill" of Model "94" in early 1935, J. J. Kirschenbaum joined the Supply organization. At that time a second toolroom on the hill was added, and in late 1935 a stock account was established when the first warehouse building was constructed. The Mississippi River Commission (MRC) retained responsibility for purchasing and property record accounting during the early stages of WES growth. Supply function then consisted of responsibility for maintaining toolrooms, maintaining a stock account, placing requisitions for materials and supplies with MRC, physical receipt of materials and supplies for which receiving records were forwarded to MRC for payment, and maintaining a "hand receipt" system of property record keeping.

3. During the late 1930's, MRC gradually delegated more and more authority to WES in these areas. In 1939, responsibility for a complete WES property accounting function was handled by Supply with accountability vested in MRC. In 1941, small purchase authority to $100.00 was granted by MRC to WES. In addition, WES Purchasing Agents assisted the MRC in finding needed materials and equipment and in soliciting bids. In 1943, the MRC satellited WES on the Vicksburg District for major purchases. In 1943 also, transportation agent authority for shipment of materials and supplies was delegated to Supply.

4. The World War II years found Supply with the difficult mission of obtaining scarce materials and equipment with most WES activities not having a high enough priority to acquire them. Purchasing was more a function of "finding" than "procuring." During this period Messrs. S. W. Watson and John R. Reeder, who joined Supply in 1941, "scrounged" supplies by the "beg and plead" method. They also maintained constant liaison with Army installations in Mississippi and nearby states which netted some "cast-off" supplies and equipment which were rehabilitated for WES use.

5. Shortly after World War II, when WES started to become completely self-supporting, Supply likewise became a complete organization with the addition of a Contract Section under Mr. E. H. Teeter in early 1948. At that time, all Supply activities necessary to support WES were available from the WES Supply staff. Continued growth of WES resulted in the need for support of in-house activities by

obtaining the services of professional organizations and educational institutions by contract. The growth of this activity resulted, in 1964, in the final reorganization of the Contract Section into a Contract Branch consisting of Advertised Contract Section, Negotiated Contract Section, and Contract Administration Section headed by Mr. A. J. Breithaupt, Mrs. Connie A. Mattingly, and Mr. W. W. Whatley, respectively.

6. In early 1953, the change in concept of the property accounting function from an operating organization to a financial accounting organization caused an OCE directive which transferred the Property Accounting function to the Comptroller organization. The Supply organization then included functions of open market and contract purchasing, responsibility for physical handling and operational property duties, storage, distribution, receiving, and shipping. These functions remain unchanged and constitute the mission of the Supply and Procurement Office of today.

7. The Supply organization operated from its inception as a unit of the Operations Division until 1937 when it became a unit of the Administration Division under Mr. J. H. Moore. In early 1946, Supply again became a unit of the Construction Services Division; then on 1 January 1947, it became a separate unit of the Administrative Staff where it has remained since. Those serving as chief of the Supply organization have been Messrs. S. W. Watson, 1933-1946; Morgan L. Warren, 1947-1952; and John J. Kirschenbaum, 1953 to date.

8. A partial list of "old time" employees is as follows: In 1936, Messrs. W. C. Clark and Robert Meeks joined the Supply organization; in 1938, Messrs. Glen P. Johnson and Fred Davis; and in 1940, Messrs. Fast, Stapleton, McClatchey, Tonner, and Ridley. In 1943, a new milestone was passed when members of the fairer sex became a part of Supply staff. Many of the older members of the Supply organization served during World War II and some were recalled during the Korean War.

Purchasing Branch

9. The purchasing function at WES started in 1933 as pickup assistance to the MRC Contracting Office. Later in the 1930's, Supply personnel began soliciting bids and finding materials and equipment for the MRC Purchasing Office. In 1941, Mr. S. W. Watson was delegated authority to sign purchase orders for small dollar value purchases of locally available items; the MRC still handled larger purchases and contracts. The amount of delegated authority increased as purchasing proficiency grew; and in 1946, the maximum open market authority allowable of $100.00 per purchase was granted to WES. Keeping pace with changes in regulations affecting small purchase authority, WES continued to get the maximum allowable which is now set at $2500.00 per purchase.

10. Growth of WES caused organizational expansion, and in early 1948, the procurement function, headed by Mr. John J. Kirschenbaum, Jr., was broken down into Open Market and Contract Purchasing Sections. Open Market Section later became the

presently designated Purchasing Branch. Mr. John R. Reeder was the first chief of Open Market Section, succeeded in 1949 by Mr. G. T. Edwards; and after an absence from WES, Mr. Reeder again became Chief of the Purchasing Branch in January 1968 upon Mr. Edwards' retirement.

Contract Branch

11. As a result of the need for support of the in-house capability through services of professional organizations and educational institutions, in early 1948 the Director was delegated full Contracting Officer authority and a Contract Section was added to the procurement organization. This section had to pioneer in the use of cost type contracts for procurement of research services, because in the late 1940's, regulations had not been written to cover this aspect of contractual activity. The first Contract Section was headed by Mr. Earl H. Teeter, assisted by Misses Katie Evans and Connie Avery (Mattingly). In addition to the functions its name implies, the Contract Branch also is responsible for loans, transfers, and disposal of property; it serves as liaison for WES with the Vicksburg District for real estate matters and with Legal Counsel, MRC, for legal matters pertaining to contracts. This branch has not only taken care of WES needs to fulfill its mission but has assisted in procurement in support of Southeast Asia by executing and administering multimillion dollar production contracts of landing mats and membranes.

Supply Control and Distribution Branch

12. From the two-man, toolroom operation in 1933, Supply had added the operation of a stock account by late 1935. The primitive, hand-receipt property accounting system in the mid-1930's grew to a full-fledged property accounting and operation function in 1939; and in 1946, complete accountability and responsibility for property was vested in WES by the appointment of a WES Accountable Property Officer. Similarly, responsibility for receiving supplies, with notification thereof to MRC, eventually led to complete responsibility for inspection and acceptance of materials and supplies in 1940. Similarly, also, requests to MRC for shipment of supplies and equipment became a function of WES with the appointment of WES transportation officer and transportation agents in 1943. Mr. Carl Fast headed the Warehouse Unit from 1941 to 1946, Mr. George Herndon from 1946 to 1954, and Mr. W. C. Clark from 1954 to present. Mr. C. F. Trevilion has headed Receiving and Shipping Section since 1954, and Mr. E. L. Nelson has headed Stock Section since 1962.

Appendix XV

REPRODUCTION AND REPORTS BRANCH

1. This appendix describes first the evolution of the present Reproduction and Reports Branch, and then takes up the development of each of the four Sections of the Branch separately.

2. The first element of the Reproduction and Reports Branch to come into being was the Photography Unit, which was organized in 1933 and consisted of a staff of two with F. B. Gautier in charge. In 1936, a Drafting Section of two employees was set up with H. K. Roberts, Jr., in charge. In 1937, the Photography Laboratory and the Drafting Section were combined in a Drafting and Photography Section under R. R. Conner, which reported through the Executive Officer to the Director. In 1938, a Reproduction Unit of three employees, with J. M. McCaskill in charge, was organized under the Construction Section whose Chief was C. R. Warndof.

3. In 1941, the Drafting, Photography, and Reproduction Sections were made components of Laboratory Services, under J. B. Tiffany. R. D. McCary had succeeded H. K. Roberts as Chief, Drafting Section. The Sections had grown somewhat by then, as described subsequently in the discussion of each Section, and they expanded much more during the period of World War II, when women were first employed in these Sections. In November 1941, Mr. Tiffany combined the three Sections into a Reproduction Branch and appointed J. M. McCaskill the Branch Chief.

4. By 1944, most of the original employees of the three Sections had gone into the Armed Services. The Reproduction Branch became the Reproduction Division under DeKalb Wylie with M. L. Anderson in charge of the Photography Section, C. H. Lefeve in charge of the Drafting Section, and E. L. Price in charge of the Printing and Lithography Section. The three Sections had 29 employees, and were kept busy with war-effort work.

5. In 1946, the Reproduction Division was redesignated the Reproduction Branch. J. M. McCaskill returned from the Army and resumed his job as Chief of the Branch. Floyd Mobley was made foreman of the Field Print Shop. R. D. McCary and F. B. Gautier had also returned from military service and were again in charge of the Drafting and Photography Sections, respectively. The strength of the Branch had increased to 49 by this time.

6. In 1950, the Reproduction Branch was made part of the Technical Services Division, of which J. B. Tiffany was Chief. Late in that year, the Reports Branch, which had been a component of the Research Center (another element of the Technical Services Division), was transferred to the Reproduction Branch, as the Reports Section, with Katharine H. Jones in charge. This reorganization unified all groups engaged in preparing material for and printing reports, thus providing better coordination and control of report processing. The Reproduction Branch was then

redesignated the Reproduction and Reports Branch. The strength of the Branch, organized as it is today, was 68.

7. In 1951, the Technical Services Division was put in charge of C. B. Patterson.

8. In 1953, the Reproduction and Reports Branch, whose Sections had been located in several buildings near the Main Building, moved into a new wing of the Main Building. For the first time all sections were quartered under one roof, which effected a considerable improvement in efficiency because of the constant interchange of work. This happy situation lasted until the "Fire" of October 1960, which destroyed the quarters and all equipment of the Branch except the big copy camera (even it was severely damaged). In addition, the photographic negative files, several completed, complicated printing jobs, and some report drafts (in the Reports Section) were lost.

9. With no housing available for the Branch on the WES reservation, the Drafting, Reports, and Printing Sections (except for the big copy camera) were moved to unoccupied space in the headquarters building of the National Park Service, about four miles from WES. Temporary quarters were hastily constructed in a cleared area of the burned building for the Photography Section, and a shelter was built around the big copy camera.

10. Most of the equipment needed to put the Drafting, Photography, and Reports Sections back in operation was not very difficult to obtain. Some could be purchased locally, and some was borrowed from other Government offices or from commercial firms until the items ordered were received. These procedures enabled these Sections to get back in operation within a week. However, this was not true of the Printing Section. The measures used to get it back in operation are outlined in the discussion of that Section.

11. In February 1962, the Reproduction and Reports Branch was made an independent Branch of the Advisory and Administrative Staff, under J. B. Tiffany, Technical Director.

12. In 1963, all Sections of the Branch moved into the new WES Headquarters Building. However, almost before these quarters were finished, the work load and, consequently, the staff of the Branch had increased so much that the allotted space was not adequate. To relieve the crowded conditions throughout the entire Headquarters Building, a new Reproduction and Reports Branch Building was authorized and was completed in 1966. The building provides excellent working areas for the Drafting, Photography, and part of the Reports Section. The Field Printing Plant and the Publications Distribution Unit are still in their original quarters in the Headquarters Building, but future plans call for additions to the Branch Building that will again put all elements of the Branch under one roof. The strength of the Branch is now 91.

13. On 12 April 1968, Mr. McCaskill retired after 35 years of Federal Government service. The retirement ceremony was attended by one of the largest audiences

on record for such a ceremony. Katharine H. Jones was appointed Chief, Reproduction and Reports Branch, effective 14 April 1968.

Photography Section

14. The design for the original main building provided for a one-room photo lab. However, before 1933 there was no official photographer, and photography was done by I. H. Patty; at times LT H. D. Vogel, then Director, shot movie footage. Negatives were processed in town, with the contact prints made at WES. Back in those leisurely days, prints were dried in the sun, so there were very few requests for rush jobs.

15. During the period 1933-1937, the staff of the Photography Section consisted of M. L. Anderson and F. B. Gautier, with the latter in charge. J. M. McCaskill and I. C. Harper worked in the lab for short periods. A dark room was added for processing negatives and slides and, as the work load increased, cameras and lights were purchased. Our first 4x5 synchro-flash camera was purchased during this era.

16. During 1938-1939 Hugh Allgood, Walter Langston, and Harley Straight were added to the staff, and the photo lab was moved to new quarters which provided space for additional print rooms and for a small copy camera.

17. The Galveston Harbor model was the first on which photography was used extensively. A special shelter was erected housing an 8x10 camera 25 ft above the model, and permanent lights were installed. Approximately 2500, 8x10 photographs were made of surface currents. Model-prototype scales, important locations, plan number, hour, ebb-flow arrows, etc., were included to provide a comprehensive photographic record of each test.

18. During World War II, M. L. Anderson was in charge of the Photography Section, with Mildred Miller as assistant. Messrs. Jean Selby, Lee Jones, Steve Mattingly, and James Litton were employed as photographers. In addition, several women were employed as lab technicians; these included Mrs. Patterson, Arlene Cavanaugh, Mary Cain, Pauline Brown, Averine Allen, Mary B. Wood, Catherine Hartley, Evelyn Headley, Dorothy Brumitt, Catherine Ray, and Eva Ray. Photographic coverage changed from only hydraulic model photography to include defense-related activities in soils and flexible pavement projects. At one time there were 19 people in the Section.

19. In 1945, Mr. Allgood resigned to enter private business. R. M. Rudd transferred from the Printing Plant to the Photography Section and John Turner was hired as a motion picture cameraman. In 1946 the staff was reduced by 50 percent in the historic RIF of that year. F. B. Gautier reassumed charge of the Section in October 1946. During 1947-1950, C. M. Hamilton and W. D. Rutland were added to the organization.

20. During the 1950's the first 16mm film reports were made for the WES and Mississippi River Commission. The first film report, "Problem at Port Washington,"

was produced in the summer of 1950. High-speed cameras and custom-built electronic flash units were acquired in 1950. Both types of equipment are still in service.

21. To meet the increased work load, it became necessary to buy automatic equipment for processing negatives. This equipment has made it possible to process several hundred negatives daily, has increased production, and has provided quality control. New equipment has also been purchased to facilitate the making of slides.

22. During the period 1963-1967 the following were added to the staff: R. B. Ball; J. S. Smith; H. W. Tompkins; J. H. Lindsey; G. W. Newman; and J. W. Turner, Jr., who transferred to the Vicksburg District in 1947 and returned to the WES in 1965. Mr. Smith resigned in 1967.

23. In 1966 the Photography Section moved to its present location in the Reproduction and Reports Branch Building. The physical plant is on a par with the best in the South. Four separate processing rooms are available, plus automatic processors for film and paper, and motion picture editing equipment.

24. A major breakthrough in photographing tidal models has been accomplished. By using electric shutters which are actuated simultaneously by the model tidal mechanism, it is possible to secure precise time exposures on the several cameras used to photograph problem areas. By flashing a controlled electronic light, a dot is produced on the floats which trace the surface currents and thus indicate the direction of flow. Bottom current directions are shown by dye crystals, and bottom velocities by tracing the path formed by ping pong balls that have been injected with salt water so that they travel on the bottom. For long time-exposures varying from 30-60 seconds, required for extremely slow currents, flashlight bulbs powered by small batteries packaged in styrofoam provide an ideal method for tracing current directions.

25. Approximately 30 motion picture film (16mm) reports have been produced and are currently in the WES circulating library. Over 125,000 negatives are on file. Although the work load has increased considerably over the years, the present staff consists of 10 photographers--half that of the World War II peak. The capabilities of the Section have increased, however, to meet the specialized demands of the operating divisions. The Section is now geared for maximum speed and service.

26. The following is a fairly complete list of personnel who have been employed in the Section.

Averine Allen
Elmo Allen
Hugh Allgood
M. L. Anderson
Ronnie Atkinson
R. B. Ball
Mary Bell Bobb
Pauline Brown
Dorothy Brumitt
Mary Cain
Arlene Cavanaugh
Stuart Easterby
Darrel Elsea
E. W. Frost
F. B. Gautier
Mary B. Habeeb
C. M. Hamilton
I. C. Harper
Catherine Hartley
Evelyn Headley
John January
Lee Jones
W. L. Langston
J. H. Lindsey
J. C. Litton
J. M. McCaskill
Jack McCaskill
R. F. McCord
George McKinley
Steve Mattingly
Helen May

Mildred Miller	C. R. Robb	Billy Sheppard
Billy Moore	Willie Robinson	John S. Smith
G. W. Newman	Virginia Rounsaville	H. M. Straight
Charlene Nutt	R. M. Rudd	H. W. Tompkins
Mrs. Patterson	W. D. Rutland	J. W. Turner, Jr.
Catherine Ray	Jean Selby	Horton Webb
Eva Ray	Lynn Shelton	R. T. Whatley

Drafting Section

27. Prior to 1936 all drafting at WES was done by the project engineers, and consisted of flood and ebb patterns on movable-bed tidal models, model layouts, designs of dams, but principally scour patterns of sand bed models, all drawn on large, 27- by 40-in. sheets.

28. The Drafting Section started in 1936 with two draftsmen, and by the early part of 1939, had increased to five people. At this time, WES was beginning to grow and more models were being built, so the Drafting Section started recruiting for more draftsmen. It was realized that the size of the drafted sheets was getting to be a problem because they had to be folded to fit in reports. It was suggested by J. B. Tiffany that a set of standards be set up which would permit drawings to be reduced photographically to fit into reports and still maintain uniform sizes of lettering. He and several other engineers got together and came up with a final border size of 6 by 9 in. and an overall sheet size of 8 by 10-1/2 in. for all reports. The Drafting Section drew up and published a set of standards consisting of 20 pages of data to be used as a guide for WES reports.

29. In the following years, draftsmen were here today and gone tomorrow; most went to the Army, Navy, and Marine Corps. This was when we hired our first women draftsmen and taught them how to draw on the job.

30. In February 1958, J. B. Tiffany wrote Station Memorandum No. 108-2 on "Preparation and Use of Slides," which is still being used in preparing material for presentation in talks, and by schools, etc.

Field Printing Plant

31. In 1938, a multilith and photomaking equipment were lent to the WES by Company B, 106 Engineer Battalion (Mississippi National Guard), with the understanding that members of Company B employed at WES would operate this equipment to gain experience and training while producing the printing for WES. The equipment and personnel (3 employees) were placed under C. R. Warndof, Construction Services Branch, who was also Company Commander of Company B.

32. J. M. McCaskill (Master Sergeant in the National Guard) was sent to Fort Belvoir, Virginia, for a three-month course in photography and lithography, and upon his return in December 1938 was placed in charge of the Reproduction Unit.

33. Some expansion of the unit was begun in 1939 when Jean Selby, Emmett Gautier, and Gordon Cheek were employed and a duophoto (photographic copier) was added, along with a mimeograph and assembly table.

34. In 1940, the National Guard was called to active duty and some of the personnel (I. L. Sorensen, Gregory Hutchinson, Ryland Rudd, Gann, and Gastrell) along with the National Guard equipment were moved from the station. To replace the printing equipment, a 17- by 22-in. offset press and platemaking equipment were purchased. There were 8 to 10 employees in the Reproduction Section during the period from 1940 to 1942, with a heavy work load of printing, duophoto, and bindery work. In March 1942, J. M. McCaskill, who was functioning as Section Chief as well as Branch Chief, was called to active duty and Mr. Thurman was made Acting Chief. He was subsequently replaced by Karl Dupes, who was later replaced by DeKalb Wylie.

35. In 1944, J. M. McCaskill was stationed at the Army Map Service in Washington, D. C., and during this assignment he requested the Reproduction Section to assist in the war effort by printing several 1:62,500 quadrangle maps.

36. In early 1946, the MRC printing plant, including all of the equipment (letterpress and monotype) and three employees, was moved from St. Louis to the WES. At this time the Reproduction Section became the MRC Field Printing Plant, with Floyd Mobley as plant foreman. During this same period a large copy camera was moved to WES from the Vicksburg District, and R. F. McCord was transferred to the Station as operator of the camera.

37. For about a year, efforts were made to operate the letterpress equipment, with very little success as the monotype equipment was too slow to set type for the short runs that comprised the work for the press. Messrs. Tiffany and McCaskill, being thoroughly convinced that this equipment would not work out, went to the Commission and convinced Mr. Charles Schweizer and others that this obsolete equipment should be replaced with modern offset equipment. This was accomplished, and an additional 22- by 29-in. offset press and one multilith were purchased.

38. In October 1960, all of the equipment of the Printing Section (except the big copy camera) was lost in the fire mentioned earlier. Because of the paper work involved and the long delay in the delivery of printing equipment, it was estimated that it would take six months to a year to obtain complete replacements for the equipment. Since this type of equipment could not be borrowed locally, the Director, COL E. H. Lang, and Mr. Tiffany sent Mr. McCaskill to Washington to try to get some printing equipment on a temporary loan from some other Government agency. Through the efforts of John R. Richardson and John Doneghy of the Office, Chief of Engineers (OCE), four field units (two press vans, photography van, and layout and platemaking van) were located at Fort Belvoir, Va., where they were being used for training purposes. As this was military equipment, and at WES it was proposed to use it for Civil Works reports, there seemed to be quite a problem. However, it was finally settled, and Fort Belvoir was instructed to deliver the

equipment to WES for a six-month period, after which time it was to be returned to Belvoir. The equipment arrived in about three weeks and was in operation one week after it was received. This made it possible for the printing plant to be back in full production in less than one month after the fire.

39. A list of replacement equipment for the printing plant was prepared by Messrs. Mobley and McCaskill and taken to Washington by Mr. McCaskill who, along with representatives from OCE and The Adjutant General, met with the working committee of the Joint Committee on Printing for the purpose of obtaining approval from this committee for the replacements. Final approval was received in about two weeks.

40. At the end of six months, all of the temporary printing equipment except one press van was returned. In another 90 days, the last press was returned and the plant was back in full operation with permanent equipment.

Reports Section

41. The Reports Branch was established in 1946 during the general reorganization of WES following World War II. Until that time, each technical division had prepared the reproduction copy of its technical reports, with the only central control being that exercised by the Director and Executive Assistant in their review of the reports. J. H. Moore, Administrative Assistant, suggested to the Director, COL C. T. Newton, early in 1946 that a central function be set up for processing the technical reports of all the technical divisions to ensure uniformity of style and format, and to improve the appearance and readability of WES reports. The Reports Branch was inaugurated as a unit of the Engineer Department Research Center, of which C. B. Patterson was Chief. Katharine H. Jones, on return from military service in August 1946, was designated Chief of the Reports Branch. As of 1 January 1947 the Branch, though authorized seven people, consisted of only the Chief and one typist!

42. It is of interest that the format for WES reports was evolved by J. B. Tiffany, Jr., in the 1930's when he was a project engineer and was required to write technical reports for which there was little or no precedent.

43. By July 1947, the Publications Distribution Section (consisting of one clerk) had been transferred to the Reports Branch from the Research Branch of the Research Center because its function was more closely allied to the work of the Reports Branch. Also by this time, the actual strength of the editorial staff had increased to 6. In 1947, four WES Bulletins and 21 Technical Memoranda (TM's) were published.

44. In 1948, the Reports Branch was divided into an Editorial Section, consisting of 5 editorial clerks and a varitypist under Ida K. Harkins, and a Distribution Unit under Mary Alice Kling assisted by one clerk-typist.

45. In 1949, the Research Center became a part of the Technical Services Division, of which J. B. Tiffany was Chief. The Reports Branch staff had increased to 11. One Bulletin, 49 TM's, and 3 Miscellaneous Papers were published. (The Miscellaneous Papers were not given this designation until this series of reports was inaugurated in 1952, but the three reports were actually published in 1949.)

45. Late in 1950, the Reports Branch was transferred to the Reproduction Branch as the Reports Section, and the Branch was redesignated the Reproduction and Reports (R&R) Branch.

47. In the early 1950's the Reports Section undertook for the Mississippi River Commission (MRC) and the Vicksburg and New Orleans Districts copy preparation of the annual pamphlets entitled "Stages and Discharges of the Mississippi River and Tributaries." This work has been continued each year (though most of the tabulations are now done on an electronic computer), and numerous other periodic and special publications have been and continue to be prepared for the MRC, Lower Mississippi Valley Division, and its Districts.

48. About 1951, Margaret J. (Jo) Powers was designated Chief of the Distribution Unit. In that year, at the direction of Mr. Tiffany, the bimonthly publication of a list of the reports in the Reports Section and Printing Plant, entitled "Priority for Editing and Printing," was begun. This list is still used as the basic work schedule for the Reports Section, and also serves to inform the technical divisions of the publication schedule for their reports.

49. As mentioned earlier, the Miscellaneous Paper (MP) series of reports was established in 1952. Its purpose was to promote making of record minor investigations or data which otherwise might not be reported at all, as well as to remove from the primary report series (the TM's) reports of limited scope or interest.

50. In 1953, James T. Herbert was designated Chief of the Editorial Unit.

51. By 1955, the Reports Section staff had increased to 18 with the addition of editors, proofreaders, typists, and another clerk in the Distribution Unit. The last WES Bulletin, No. 40, was published in 1955, it having been decided that the type of material included in this series would receive wider distribution if published in professional journals. All papers so published were also to be bound as MP's and copies filed in the Research Center Library so that all Corps personnel would have ready access to them. A total of 32 TM's and 32 MP's were published that year, showing that the MP series had gained popularity. About this time, too, the Reports Section began preparing the reports of the Committee on Tidal Hydraulics for publication. This work as well as preparation of various types of reports for OCE has continued ever since.

52. In the fall of 1955, Military Construction, OCE, under COL C. T. Newton, set up an Ad Hoc Committee to establish procedures to be used by the Corps laboratories in preparing technical reports. Mr. Tiffany offered the services of the Chief, Reports Section, to assist the Committee in this work. At that time, WES

was the only Corps laboratory which had published its own guide for preparation of reports* and also it had the most complete publication facilities of any of the laboratories. Katharine Jones met with the Committee, made trips to or corresponded with the other Corps laboratories to learn their procedures, and prepared a draft of a report preparation guide for the Committee's review. The resulting "Guide to Good Practice in Technical Report Preparation" was published in April 1956. The principal changes that it effected in WES reports were the change of the designation "Technical Memorandum" to "Technical Report" and establishment of the Research Report (RR) and Instruction Report (IR) series. The first IR was published in 1956 and the first RR in 1957.

53. In 1958, the organization of the Reports Section was changed by the grouping of the typists and proofreaders into a separate "Copy Preparation Unit." Edabeth F. Vavra was named Chief of the Unit, which comprised a Standard Machines Subunit under Rosemary M. Schaff, which prepared primarily WES reports using standard typewriters and elite type; a Special Machines Subunit under Jo K. Rawdon, which prepared special reports primarily for other CE offices on proportional spacing typewriters and varitypers, and furnished lettering for the Drafting Section; and a Proofreading Subunit (consisting of Leila N. Lambert and Beatrice B. Hovious), which was directly under the Unit Chief.

54. In the fall of 1959, Jim Herbert transferred to another office and Katharine Jones assumed the additional duties of Chief, Editorial Unit. Rosemary Schaff transferred to the Editorial Unit as an editor, and was replaced as Chief, Standard Machines Subunit, by June T. Herbert. In that year, 2 IR's, 51 TR's, and 64 MP's were published.

55. In the October 1960 fire in the Main Building, a good many reports that were being processed in the Section were lost, but the technical divisions were able to reconstruct most of them. Only one report each of the Soils and Hydraulics Divisions was completely lost and had to be rewritten. Three translations were lost with the original foreign-language text and could not be replaced.

56. In March 1961, the Reports Section undertook for Military Construction, OCE, the editing and copy preparation of a large backlog of Guide Specifications (both Permanent and Emergency) and Technical Manuals. This work occupied an editor and two typists and a considerable amount of the proofreaders' time through 1966. In that time approximately 150 Guide Specs were completed, which brought the specifications up to date, a project which had been receiving the attention of the U. S. Congress. Also, about 50 Technical Manuals were completed. Revisions or new items, particularly in the Technical Manual category, are still received from OCE occasionally, but no longer constitute a significant part of the work load.

57. In 1962, Richard T. Smart was named Chief of the Editorial Unit.

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* MP 5-128, "Guide for Use in Preparation of Waterways Experiment Station Reports," May 1955.

June Herbert resigned, and Mary B. Pikul became Chief of the Standard Machine Subunit.

58. In 1963, the Research Center Library completed a compilation of all reports it could locate that had been prepared for WES by contract. The Contract Report series was begun with this compilation, and new reports were added to the series during the year. Also in 1963, the Distribution Unit was requested by the Publications Division, OCE, to stock and sell to the public some 50 Engineer Manuals. This has added considerably to the work load of the Unit as these Manuals are in constant demand.

59. During 1962 and 1963, the work load of WES reports continuously increased and with the added work in connection with the Guide Specs and TM's for OCE, the backlog of reports being processed in the Reports Section became of concern. Through continual efforts, more personnel spaces were obtained and personnel were recruited so that the strength of the Section grew from 23 in 1962 to 33 in 1965. As the new employees became trained, the output of the Section increased and the backlog steadily decreased.

60. In June 1964, the first Army Regulation dealing with the preparation, publication, and distribution of technical reports was published as AR 70-31, "Standards for Technical Reporting." Prior to its publication, OCE sent a draft of the proposed AR to WES for comments, which the Reports Section supplied. Apparently some of them were acted on. The principal effects of the AR on WES reports were:

- a. To emphasize prompt completion.
- b. To change the format of report covers.
- c. To add a distribution statement, disposition instructions, and disclaimer to report covers.
- d. To require that a distribution list be included in every report.
- e. To add a Form 1473, Document Control Data - R&D, to each report, primarily for the use of the Defense Documentation Center.
- f. To change the manner of listing references.
- g. To establish that contract reports should also follow the format established by the AR.

The AR gave proper recognition to the Army's technical reports program, was beneficial in standardizing and regulating certain aspects of format, content, and procedures, and gave increased impetus to the WES reports program.

61. In September 1964, Station Regulation 335-3 was published to implement the AR (OCE did not publish an ER for that purpose until 1967). One of the innovations of this SR was the establishment, at the direction of the Director, COL Alex G. Sutton, Jr., of a keyman for reports in each technical division "to serve as the division chief's principal assistant and expediter" of reports and "to act in a liaison capacity with the Reproduction and Reports Branch." This central control for reports, where fully utilized, has been very helpful from the Reports Section's standpoint.

62. In 1965, a Proofreading Subunit of 6 people, with Bea Hovious as Chief, was established as part of the Copy Preparation Unit. In the fall of that year, the need for an additional editor became urgent and Beth Vavra transferred to the Editorial Unit. Thereafter, the Copy Preparation Unit was dissolved for a time, and each of its Subunits became a Unit reporting directly to the Section Chief. Also in 1965, the need became evident for editorial assistants to assist the editors with mechanical details and relieve them of as much "legwork" as possible. Two such positions were established, one in each of the typing units.

63. By the end of 1966, the Editorial Unit had reached a strength of 6, which appeared to be optimum for the work load, and was meeting the goal of no more than two months in editing for routine reports. However, by the fall of 1967 two editors had resigned and a "freeze" on hiring prevented replacing them. To give the reduced editorial staff as much help as possible, two editorial assistants were transferred from the Standard Machines Typing Unit to the Editorial Unit and physically placed near the editors to be more accessible to them. This has been of material help in meeting the time requirements for report completion.

64. Also in the fall of 1967, the Copy Preparation Unit was reestablished in order to make optimum use of the personnel in the three subunits by closer coordination of the work. Mert Pikul was put in charge of the Copy Preparation Unit and Lucille B. Logue was promoted to Chief, Standard Machines Typing Subunit. In December, Jo Rawdon retired--the first employee of the Reports Section to qualify for retirement. Evelyn M. Luckett was promoted to Chief, Special Machines Typing Subunit. At the end of the year, the inability to fill vacancies had reduced the staff to 30.

65. In September 1967, IR 9, "Guide for Preparation of Waterways Experiment Station Technical-Information Reports," was published to supersede the long-outdated MP 5-128 of 1955. It was principally the effort of Dick Smart, and was a much-needed and very helpful step toward standardizing the format and style of WES reports.

66. In 1967, the following WES reports were published: 2 IR's, 105 MP's, 74 TR's, and 19 CR's. In addition, the annual supplements to TM 6-370 and TR 6-553, the quarterly supplements to the Handbook for Concrete and Cement, a Mississippi Basin Model report, a Potamology report, the Annual Summary, and 12 translations were published, a total of 221 technical publications.

67. In April 1968, Dick Smart took over as Chief, Reports Section, when Katharine Jones was made Branch Chief.

Appendix XVI

PERSONNEL OFFICE

1. Prior to the beginning of World War II the WES had two to three clerks who performed duties associated with personnel. At that time, WES administrative activities were under the supervision of the Administrative Assistant of the Mississippi River Commission (MRC) and followed those management policies which the President, MRC, made known to the WES. Personnel procedures performed during this period constituted legwork to be used by the Personnel staff of the MRC in its overall program. At this time, also, the MRC did not have appointing authority nor did they have authority to classify positions. We found ourselves frequently writing recommendations for within-grade step increases of $5.00 per month, furnishing an abundance of documentation justifying the recommendation for this increase, only to have the recommendation returned, disapproved, with very brief comments that the reasons for the step increase were inadequate. We operated entirely without authority to take any personnel action except a separation action, which meant that any desired personnel action would have to be recommended, furnishing full justification therefor, and sent to the MRC either for their determination or for determination of higher authority.

2. In those days every supervisor was a working supervisor inasmuch as the supervisor contributed personally in performing the tasks to be completed. Supervision at that time was undefined. Supervisors were expected to get the job done, as now. The Incentive Awards Program consisted of occasional letters of commendation. Administering discipline consisted of summary discharges, written reprimands, and more often, verbal reprimands.

3. During this period employees who were considered as office workers worked only 39 hours a week, whereas the tradesmen and outside workers worked 44 hours a week. The tours of duty for office workers were seven hours a day, Monday through Friday, and four hours on Saturday. The outside workers' tour consisted of eight hours per day, Monday through Friday, and four hours on Saturday. All employees at that time received 15 days sick leave a year which could accumulate to 90 days. Annual leave was granted to all employees at the rate of 26 days per year and could accumulate to a maximum of 60 days. All employees were paid once a month, except in December, when they would get half a month's pay around the 15th or 16th to help finance them over the Christmas period. Overtime pay was unheard of and most employees had a lot of compensatory time to their credit. All employees were paid on an annual basis; a foreman of laborers may have received $1200 a year, a rodman $900, and an engineer $2000 a year.

4. The Station built up rather gradually in its early years and had from 250 to 300 employees by the early 1940's.

5. The 106th Engineers and the 155th Infantry, both National Guard units,

were called into active duty in 1940 and 1941, respectively. With these personnel losses and the losses resulting from induction into the service, and by employees volunteering for service, the Station resorted to unprecedented practices in order to keep the work going. It began to hire women for jobs that were previously held by men and by the middle of 1942 it was not unusual to see women dressed in slacks reading gages on models, moving catwalks, and performing the usual duties of engineering aids. There were women messengers and a woman timechecker; in fact, women were placed in any type position for which they qualified.

6. In March of 1942, the Civil Service Commission changed its laws governing new appointments. This was probably due to their determination that the war period would require many more civilians, many of whom would be surplus after the war and who would not fit into the career system. It authorized two types of appointments--war service indefinite and war service temporary. These Civil Service appointing authorities were utilized during the war and until competitive registers were established after the war. Many of the war service appointments were converted into the competitive service in later years.

7. The prewar Personnel Section was first headed by Martin B. Jacobson, who was assisted by L. C. Marsalis, Jr.; in the early part of 1940, W. F. Lauderdale was appointed as a third member. In the latter part of 1940, Jacobson transferred to an office in the Midwest and Marsalis was put into his job, Lauderdale into Marsalis' old job, and Joseph L. Franco was reassigned to the Personnel function. Franco was the first to leave for service in the Air Force; Lauderdale left next for the Marine Corps; and Marsalis later joined the Navy. There was considerable turnover and interchange of personnel in the Personnel function during the war years. The increase in the overall strength of the Station necessitated an increase in the number of people performing the Personnel functions. Hugh L. Calvin, Jr., who assumed responsibility for Personnel functions when Marsalis left, resigned in about 1944 and William B. Adams became responsible for Personnel functions.

8. In January 1946, there were eight people in the Personnel Section performing essentially the same duties as were performed in 1940. There were between 500 and 600 people on the rolls at that time. Large numbers of veterans were returning and exercising their reemployment rights, including Franco who returned in July 1945 and Marsalis and Lauderdale who returned in February 1946.

9. To appreciate the events that occurred in the following months, it will be helpful to review the historical developments in Army civilian personnel management. Prior to August 1942, all personnel actions were effected in Washington and all Classification Act job evaluations were preaudited and approved in Washington. With the immense work force that the Army was bringing together, it was impossible to continue to operate on a centralized basis. In August 1942, the Army undertook three basic reforms: (1) responsibility for "tailoring" policy was delegated; (2) a program evaluation system was established; and (3) responsibility for policy

execution was delegated "to the lowest practical echelon." The implementation of these reforms created considerable confusion throughout the Army as it came about when the Army was conducting the tremendous recruiting program that followed our entry into World War II. At the time the reforms were undertaken, the WES was not greatly affected because the MRC did not delegate the authority and responsibility until about April 1946.

10. Shortly after the return of Marsalis, the President, MRC, announced that he was redelegating appointing authority to the Director and that plans should commence immediately to establish a system to operate under this delegated authority. By this time the Army and the MRC had nearly four years' experience operating under the decentralized system, and the Station was able to benefit in some ways by the experience others had in this transitional period. The first consideration was sufficient space for approximately 600 201-files and "control" cards which are maintained on each employee, for a library of civilian personnel regulations, for the payroll function, and for the additional people required to perform these additional duties. Training was also a requisite and the MRC assisted greatly in this effort. Another requirement was to hire someone experienced in salary and wage administration and someone experienced in the purely administrative functions of Personnel. Written policies were also needed on all matters that would concern supervisors, operating officials, and other employees. The prospects seemed most challenging, if not insurmountable, as plans progressed, as preliminary actions were taken, and as some amendments in the time schedule were made.

11. The organization that emerged from the delegation of appointing authority to the Director was the Personnel Branch consisting of the Placement Section, Employee Relations Section, Salary and Wage Section, Administrative Section, and Payroll Section. Except for the training function (which was administered by the Visitors Section), this organization was in accordance with Army's method of organization for operating civilian personnel offices. Clerical functions formerly performed were retained and divided between the Administrative Section and the Payroll Section. The management aspects were added to personnel administration, probably the most significant action concerning the Personnel organization in the history of the Station.

12. By midyear 1946, the Personnel Office was operational and was frantically attempting to satisfy needs of all organizational elements, while at the same time trying to gain a better understanding of the principles underlying the management of human resources. Two new experienced employees were added: Sandy S. Rushing, who transferred from the Galveston Engineer District to take over the Salary and Wage Section, and John B. Mills, who transferred from the Memphis Engineer District to head the Administrative Section. L. C. Marsalis, Jr., was Chief of the Personnel Branch; W. F. Lauderdale, Chief, Placement Section; W. B. Adams, Chief, Employee Relations Section; and J. L. Franco, Chief, Payroll Section. Credit is due

Messrs. H. C. Cunningham and Jerry Lawson of the Lower Mississippi Valley Division for the assistance and counseling given to the young staff members in Personnel.

13. Many expansions were planned and some commenced in 1946. The Hydraulics Division began the process of moving "on the hill"; houses and apartments were being built for military officers and key civilian employees; the Soils Division was expanding its activities in practically all of its specialties as well as assuming new areas of investigation; and the Operations Division (later redesignated Construction Services Division) was expanding immensely to take care of new construction, including the Mississippi Basin model. In June 1946, the personnel of the Central Concrete Laboratory, Mt. Vernon, New York, were transferred to WES (Jackson Installation) and formed the Concrete Research Division (later redesignated Concrete Division).

14. During this period, recruitment of qualified craftsmen, equipment operators, and technicians was difficult and the hiring of engineers became problematical. In search of laborer and semiskilled or skilled candidates, all possible means were tried to bring WES needs to the attention of people and firms that could have possibly helped. A personnel recruiter was sent to towns surrounding the Vicksburg area to inform school officials, public officials, civic leaders, and heads of fraternal and civic organizations of WES needs and to request their assistance. WES was one of the first CE installations to visit college and university campuses for the purpose of recruiting engineers. It was the first to form a nationwide recruiting program aimed at attracting engineers interested in experimental and research type projects being conducted by WES.

15. The strength of the Station soared to about 1850 employees, and the rapid growth created many problems that could not be resolved except by supervisors gaining knowledge and experience in management. There were also problems that the Personnel staff could have handled more efficiently had it been a well-trained group not facing a continuous flow of unprecedented situations in need of clarification and solution. In retrospect, it seems that everything that was put aside or had lain dormant during the war years was now being brought out and being worked on with a tremendous sense of urgency. The fast tempo of operations created for war demands could not be lessened, perhaps for fear of losing some nebulous goal that had not been achieved because of the war.

16. In October 1946, as the Personnel Office was heavily engaged in recruitment, in-service placement, and the many associated actions, instructions were received from higher authority that action should begin to reduce the work force by approximately 35 percent. All recruitment was immediately halted, commitments were withdrawn, and reduction-in-force letters were delivered to affected employees in November 1946. The overall strength was reduced by approximately 650.

17. An unplanned loss of better qualified personnel is the concomitance of reduction-in-force. The younger and mobile professional type employees seek other

positions primarily because they feel that their opportunities for promotion are not good in a shrinking organization. These losses aggravated the problem of maintaining the needed capability to operate, plus adding to the number of shortage-category vacancies that must be recruited for later.

18. By the latter part of January 1947, some of the employees who had been separated were being called back to work, not because of another buildup but because the mission organizations were in an adjustment period wherein the across-the-board reduction had separated types of employees who were actually needed for reduced operation.

19. The period from 1947 to the beginning of the Korean war in August 1950 included increased and intensive effort in the recruitment of engineers, as well as many training courses for personnel specialists sponsored by the Department of Army. An additional significant reduction-in-force left WES strength in the neighborhood of 900 personnel. The Personnel Office was reorganized and the Health Service Section added. The reorganization was patterned after Army's employee utilization concept which arose after several years of decentralized operation. In 1949 the President, MRC, was relieved of the responsibility for WES and we began reporting directly to the Office, Chief of Engineers. The Personnel organization, in 1950, was headed by L. C. Marsalis, Jr., Personnel Officer; W. F. Lauderdale was Chief of Employee Utilization, which included the old Placement Section and the Employee Relations Section; the Salary and Wage Section was headed by S. S. Rushing; J. L. Franco was Payroll Chief; M. M. Aden was Chief of the Administrative Section; and J. G. Chambers was Chief of Health Service Section. John B. Mills, formerly Chief of Administrative Section, was now a Personnel Assistant in the Employee Utilization Section; W. B. Adams had been involved in reduction-in-force when the Employee Relations Section was abolished.

20. In August 1950, Marsalis and Lauderdale were called into active duty with the 434th Engineer Construction Battalion and were gone for about two years. During this period S. S. Rushing acted as Personnel Officer and K. B. Reid was transferred from the Jacksonville District to head the Employee Utilization Section.

21. The entry into active service of the 434th Engineer Construction Battalion and the 31st Division of the National Guard involved approximately 175 WES employees, who left within the period 19 August 1950 to 31 January 1951. By this time, the tremendous construction program was completed and although some skilled men, technicians, and particularly engineers could be scarcely spared, adjustments in work programs and recruitment compensated to some extent for these losses. In 1951, Franco was reassigned from the Payroll Section to the Employee Utilization Section as the payroll function was transferred to the Comptroller. Marsalis returned to the Station in August 1951 and Lauderdale returned in June 1952.

22. From 1952 until the fire in 1960, strength fluctuations were not as great as in the preceding 10 years and the strength of WES had leveled off to about 750. In 1953, the Personnel Office assumed responsibility for the Station training program

which was placed in the Employee Utilization Section. In the middle 1950's it became evident in the recruitment and retention of younger engineers that improvement in the program was needed. The six-month training program for the BS graduates was inaugurated and technical division operating officials were encouraged to give more responsible type duties to the young engineers. This later proved an asset to the program.

23. During this period, also, WES was designated by the Department of the Army to assist the Red River Arsenal in preparing a draft for guidance throughout Army in sick leave administration. Much of the material furnished, including the title, was incorporated into the DA Pamphlet "Sick Leave Admistration - The Positive Approach."

24. In 1957, the Deputy Chief of Staff for Personnel in its overall evaluation of personnel management activities referred to WES as having a progressive personnel program.

25. Sandy S. Rushing retired in 1958 and Charles F. Johnson, Jr., was selected as Chief of the Salary and Wage Section.

26. Improvements and refinements were made in many elements of the personnel program, such as orientation of new employees, follow-up evaluations of placements, expanded training activities, on-site assistance to supervisors, etc. A plan was worked out with the Mississippi Adult Education Department for a professor in Industrial Relations from Mississippi State University (MSU) to give basic supervisory training at WES at no cost. Several discussions were held with officials of MSU concerning the establishment of a graduate study center in Vicksburg.

27. WES was awarded one of the supergrade positions authorized by Public Law 313 and Joseph B. Tiffany was promoted into this position in November 1959.

28. The fire of October 1960 destroyed offices occupied by the Personnel Office. Fortunately, William L. Bache, Jr., Executive Assistant, arrived at the scene of the fire early and directed that a fire hose be applied to the area containing individual personnel (201) files. This action resulted in saving all but three files, a most fortunate salvage; but furniture, regulations, reference mateial, etc., were totally destroyed.

29. Recovery actions began immediately and the Personnel Office, along with Office Service and the Executive Offices, was assigned space in the office building on the bank of the lake on the hill. This building was referred to as "The Little Pentagon" by members of the Construction Services Division. J. P. White, Personnel Officer of the Vicksburg District, and H. C. Cunningham, Personnel Officer of LMVD, were very helpful in our recovery by furnishing complete up-to-date copies of the DA Civilian Personnel Regulations, forms, materials, etc. Rebuilding of records and the hiring of laborers and skilled men were begun on the day following the fire. Extra effort was evident by all members of the staff, and despite the giant

rebuilding of the personnel program, needs of the operating divisions were generally met.

30. The Deputy Chief of Staff for Personnel announced a new approach to personnel organization and operation. This new organization was the Personnel Management Assistance organization based on an operating cycle of planning, executing, analyzing, and evaluating the personnel management activities. This organization was put into effect in October 1962 but could not be followed completely in practice until adequate quarters were available. The organization that resulted follows: Personnel Officer, L. C. Marsalis, Jr.; Personnel Management Assistance Branch, W. F. Lauderdale; Training and Development Branch, J. L. Franco; Position and Pay Management Branch, C. F. Johnson, Jr.; Employment and Services Branch, K. B. Reid; Manpower Management Branch, dual assignment, J. L. Franco.

31. With the completion of the new Headquarters Building in 1963, the Personnel Office moved into new quarters on 11 June 1963 and immediately expanded its activities. The availability of the new classroom permitted space for additional training effort. In April 1964, the first Middle Manager Workshop was conducted. Lower Mississippi Valley Division and the Vicksburg District employees attended and the scheduled speakers were: MG E. I. Davis, Division Engineer; COL P. J. Galanti, Deputy Division Engineer; COL J. A. Betts, District Engineer, Vicksburg District; and COL A. G. Sutton, Jr., Director of WES.

32. During the 1962-63-64 period, additional emphasis was placed on Equal Employment Opportunities, and specific plans were made to comply with directives on this subject. Grade escalation became a concern of the Bureau of the Budget and restrictions were placed on personnel actions. Emphasis was also placed on position management, incentive awards, use of underutilized skills, graduate study for engineers, supervisory training, and engineer recruitment. K. B. Reid was relieved as Chief, Employment and Services Branch. Johnson assumed this position and George A. Wilkerson became Acting Chief, Position and Pay Management Branch.

33. WES acquired the services of one engineer through the Refugee Scientists Program, Office of International Relations, National Academy of Sciences. Several engineers and scientists were appointed under the Defense Science Immigration Program, and the Army Research Office, Durham, North Carolina, assisted in effecting personal service contracts for foreign talent.

34. A cooperative education program was considered in 1964 and the first agreement with Mississippi State University was approved in April 1964.

35. Mrs. Thelma B. Williams was appointed as clerk-typist in the Personnel Office on 16 March 1964, the first Negro to be assigned in this office.

36. In the early part of 1965, WES representatives worked closely with city officials to alleviate a serious traffic problem on Halls Ferry Road (main route to and from WES). This effort resulted in the Station staggering its work hours to produce a more uniform spread of traffic flow in the mornings and afternoons. This

became effective 23 February 1965 and was of immediate benefit to both employees and the community.

37. As an additional service to employees the Director, COL John R. Oswalt, Jr., granted space to the Mutual Credit Union for a branch office on WES grounds.

38. After renewed negotiations with officials of Mississippi State University, the Vicksburg Center for Graduate Study in Engineering, a Resident Center of Mississippi State University, was formally established in the third quarter of fiscal year 1965. Dean of Engineering, Harry Sumrall, manifested intense interest in this effort and vigorously pursued the establishment of the Center.

39. There were 14 youths employed under the Youth Opportunity Corps, in addition to 30 engineering and science students, during the summer of 1966.

40. A Negro supervisor was appointed for a tour on the WES Safety Committee in August 1966, the first Negro to serve on the committee.

41. A continuing need for qualified technicians prompted trips to Junior Colleges in the fall of 1966 and the spring of 1967 to recruit students in two-year terminal courses. Interest was shown by students and faculty and this could very likely result in an excellent source of technicians. WES also assisted Utica Junior College (Negro) in curriculum changes to meet changing needs of government and industry in the area.

42. George A. Wilkerson, Chief, Position and Pay Management Branch, accepted a two-year tour with DA in Thailand on 2 May 1967. Lee C. Marshall, Jr., was appointed as Acting Chief of this Branch.

43. Charles F. Johnson, Jr., Chief, Employment and Services Branch, accepted a two-year tour with the Mediterranean Division, Corps of Engineers, Leghorn, Italy, and was transferred 2 November 1967. Joseph L. Franco, Training and Development Officer, was selected to fill this position.

44. Vernon M. Welch, Jr., was selected to fill the Training and Development Officer vacancy, and Mary J. McCary was selected to fill the Manpower Management Branch Chief position vacated by Vernon M. Welch, Jr.

45. The following are the names of former and present employees of the Personnel Office.

William B. Adams
Marvin M. Aden
Dennis Andricks
Ernest F. Allen
Milton Applebaum
Nora J. Beasley
Eddie Bishop
Billie M. Boone
Catherine H. Brabston
Hugh L. Calvin, Jr.
John G. Cesare
John G. Chambers
Ralph D. Chiti
Mary E. Cunningham
Charles V. Davidson
Dorothy L. Dean
Harold Dees
Jack M. Dial
Virginia Easterby
Robbie L. Edge
Rita R. Evans
Vivian S. Faulk
Peggy Ferguson
Joseph L. Franco
Lonnie L. Freeman
Margaret B. Gordon
Ann S. Green
Edward E. Guiney

Margaret C. Halford
Willie E. Harvey
Marjie Hearn
Ralph L. Hester
Carolyn D. Hines
Buelah S. Hudson
Martin B. Jacobsen
Charles F. Johnson, Jr.
Mary C. Jones
William F. Lauderdale
Dorothy Laughlin II
Angelina Lavecchia
Alice H. Layton
Mary Lou Lee
Lois L. Marsalis
Luther C. Marsalis, Jr.
Lee C. Marshall, Jr.
Myrtle F. Martel
Frances M. Massa
Margaret S. Mobley
Mary Jo McCary
Judy H. McCollum
Harold R. McDonald
Mary T. McDonald
Ruth McDonald
George W. Metz
John B. Mills
Alma G. Palermo
Bertha Ragsdale
Juanese Raines
C. A. Randall
Kenneth B. Reid
Marjorie A. Rein
Louis R. Renaud, Jr.
Sandy S. Rushing
Edward Ryan
David A. Saunders
Carolyn I. Schilling
Sherry J. Scott
Lynn Skeen
Billie Smith
Thomas A. Smith
Vickie Smith
Evelyn H. Stacy
Dorothea L. Vedros
Luther Warnock, Jr.
Vernon M. Welch, Jr.
George A. Wilkerson
Thelma B. Williams
Doris Womack
Mary H. Wood

Appendix XVII

OFFICE OF THE COMPTROLLER

1. The fiscal organization of the WES was formally established early in Fiscal Year 1947. Formal establishment involved the assumption of fund accountability by the Director under Army assigned Fiscal Station Number 22-079, with responsibilities for the maintenance of formal financial records, i.e., general and subsidiary ledgers, necessary to determine accountability for appropriations and allotments received and disbursed, including asset accounting for all capitalized investments under the Plant Accounts.

2. Accountability was established upon transfer of the formal accounting records from the Vicksburg District, including disbursing activities, although disbursing responsibility remained vested with the Disbursing Officer of the Vicksburg District as a dual assignment and under separate symbol until Fiscal Year 1954. Check writing, the issuance of bonds, and transactions related to these functions remained vested in the District during this period.

3. Prior to Fiscal Year 1947, fiscal functions were performed by the Mississippi River Commission or by the Vicksburg District providing administrative support, except for field cost, payroll, and property accounting activities such as are normally performed at resident, area, or project offices operating under a district. The latter were performed by the administrative staff of the Station under the direction of James H. Moore, Chief of the administrative organization. In April 1943, the Station organization chart under the Administrative Division identified the first element of the present organizational component, Office of the Comptroller, that of the Cost Section, with Hugh L. Calvin, Jr., as Chief and Ernest Faulkner as Assistant Chief. Other developments in the fiscal field as reflected by the organization chart of January 1945 revealed the evolvement of an organizational element, Accounting Auditor, with Mr. Calvin the incumbent and a Cost Accounting Section with Mr. Faulkner as Chief; John M. Pinkston, Assistant Chief, and seven employees. The latter included Ellen L. Hilton, now Ellen H. (Louise) Garner.

4. On 1 July 1946, the Fiscal Branch had evolved with Mr. Faulkner as Chief. Two sections comprised the Branch: Cost Accounting Section with Fred R. Mosley, recently returned from military duty, as Chief; and the Bookkeeping Section with Mr. Pinkston as Chief. Mr. Faulkner, Mrs. Garner, Mr. Mosley, and Mr. Moore, at that time Chief of the Administrative Branch, are the only employees of the original group who are identified with the present (Comptroller) organization.

5. The Fiscal Branch established concurrently with assumption of formal fiscal activities consisted of two sections, the Cost Section with Mr. Faulkner as Chief and the Budgets and Accounts Section with George L. Tobin as Chief.

6. First Fiscal Officer for the Station was Chris C. Tompkins, who served in an interim period (temporary detail from MRC) of two or three months. The position

was filled on a permanent basis 3 February 1947 with the transfer of Count G. Evans from the Southwestern Division. Simultaneously, the Cost Section acquired a new chief, Ferdinand L. Vogel, by transfer from the San Antonio District, Southwestern Division. Strength of the Fiscal Branch was thus initially established at 21. This compares with the present-day strength of the current organization, with its enlarged mission, of 41.

7. Scope of the fiscal activities in the first year, FY 1947, related to a dollar work program of $2,080,000 for reimbursable work and a Plant (capital investment) Program of $625,000. Gross capital (investment) expenditures through that year approximated $6 million, with a remaining book value of approximately $3.8 million. The number of reimbursable projects being conducted that year approximated 250.

8. This compares with the present (FY 1968) work program of roughly 700 projects, totaling $21.7 million, excluding special landing mat procurement (non-mission activities) for AMC and Air Force in the amount of $21.9 million; a Plant Program (capital improvements) in the amount of $2.7 million, with gross capital investment of $18.2 million and a remaining book value of $12.2 million. Figs. XVII-1 and -2 depict the progressive growth in dollar program through the years.

9. The ability to handle this increased volume of business, including the expanded activities comprising the current Comptroller organization, has been made possible through increased efficiencies and automation procedures which will be later explained.

10. The fiscal organization was initially housed in a temporary building complex, along with the Personnel Branch and the Training and Information Branch (now TLO), in front of the main administration building (now the Soils Division Headquarters Building) on the north bank of Durden Creek.

11. Within the first year of operations, Mr. Vogel resigned and the position of Chief of the Cost Section was filled by Reece A. Hough, Jr., who transferred from the Southwestern Division.

12. In January 1951, upon departure of Mr. Bache to active military duty in the Korean War, Mr. Evans was reassigned as Chief Administrative Assistant and Mr. Hough was placed in charge of the Fiscal Branch. At the same time, Mr. Moore was reassigned from Chief, Office Services Branch, to Chief, Cost Section, filling the vacancy left by Mr. Hough's reassignment. In February 1952, Mr. Hough transferred to Atomic Energy Commission in Albuquerque, New Mexico, and Mr. Evans again assumed the role of Fiscal Officer and Chief, Fiscal Branch, in a dual assignment capacity, with Mr. Mosley as Assistant Chief of the Fiscal Branch to help carry the administrative load. Concurrently, an Audit Section was established within the Branch, in conformance with OCE established organizational pattern, with Mr. Mosley as Chief of the Section in a dual assignment.

13. Effective 1 July 1952, the payroll function, including the maintenance

of leave records, which had been operating as a section within the Personnel Branch since assumption of responsibilities from the Vicksburg District in March 1947, was transferred to the Fiscal Branch as another OCE directed move to conform with Corps organizational pattern. The activity was designated Payroll Section with Edward E. Guiney as Chief and three other employees, including Nora G. Beasley, currently employed in the Personnel Office.

14. In 1952, the organization was relocated to the old Hydraulics Headquarters Building to permit removal of the temporary building complex and site preparation for the annex to the old Administration Building.

15. In October 1952, Mr. Bache returned from military duty and resumed his position of Chief Administrative Assistant; Mr. Evans returned to his permanent position of Fiscal Officer.

16. Calendar Year 1953 set in motion a series of significant events in the history of the fiscal organization as a result of the enactment of legislation and the establishment within the Corps field offices of the Army-created organizational entity concept, Office of the Comptroller. This evolvement, which originated with the 1947 Army reorganization plan, was aimed at consolidating all accounting and related managerial control functions under one staff element. The organizational element, initially established throughout the Corps, combined the Property Branch which simultaneously inherited the expendable warehouse functions or Stock Section from the Supply Branch (this function has since reverted to Supply and Procurement Office); the Management Branch, newly established; the Audit Branch, which had been a section of the Fiscal Branch, and the remaining functions of the Fiscal Branch under a new title, the Budget and Accounting Branch, comprising the one organizational entity, Office of the Comptroller.

17. First incumbent Comptroller was Mr. Bache, who assumed the dual role of Chief Administrative Assistant or Executive Assistant--Comptroller. Mr. Evans, as Fiscal Officer, became Chief of Budget and Accounting Branch; Mr. Mosley, Chief, Audit Branch; William R. Martin, Chief, Management Branch; and Raymond A. Gilbert, Chief, Property Accounting Branch.

18. As a result of the Civil Functions Appropriation Act, 1953, the civil functions appropriations were restructured, establishing functional appropriations, i.e., General Investigations, Construction, General; Operation and Maintenance, General; General Expenses; Flood Control and Mississippi River and Tributaries. These replaced such former appropriations as Flood Control, General, and Maintenance and Improvement of Existing River and Harbor Works, and created the Revolving Fund in lieu of Plant accounts that had been theretofore established under each of the civil appropriations as the single fund entity for the purpose of ownership and operation of assets, i.e., buildings and equipment, and for the furnishing of services required for multiple project use, civil and military.

19. Accounting system changes developed by the Corps in collaboration with the

General Accounting Office, required by the creation of the Revolving Fund and the restructuring of appropriations, introduced conconcurrently a changed accounting concept--from a cash accounting basis to an accrual accounting basis--placing income and expense determinations on an "as incurred" basis; for example, expenditures would be determined on the basis of evidence of receipt of goods or services as opposed to the "cash" basis where expenditures were determined on the basis of issuance of the Disbursing Officer's check. The system change brought about regulation changes vesting the disbursing function, both military and civil, in civilian staff personnel which, up to this time, was vested only in military officer personnel. The function became an added duty of the installation appointed Finance and Accounting Officer subject to approval of the Chief of Engineers and the Chief of Finance. It also set in motion the "site audit" plan for General Accounting Office review of financial transactions and of contracts. This meant the retention of the original Disbursing Officer's Money Accounts and original contracts at Corps field offices for on-site review rather than at central points to which such records and documents were formerly distributed.

20. On 23 June 1954, Mr. Evans was assigned as Comptroller in addition to his role as Chief, Finance and Accounting Branch.

21. Transfer of civil disbursing activities from LTC J. E. Windham, CE, of the Vicksburg District to Mr. Evans was ultimately accomplished on 1 May 1955, and military disbursing, which had been provided by the Army Finance Officer at Memphis, was begun at the same time.

22. The drawing of salary checks lasted only one payday after assuming disbursing functions, when OCE designated one district in each division as a central payroll office, for economy reasons. So, in the same month, payroll functions of all districts of LMVD, including those of WES, were centralized in the New Orleans District. Maintenance of leave records, however, remained at WES and was decentralized to the timekeeping level.

23. Mr. Guiney remained with the Comptroller Organization at WES and was assigned to the Audit Branch as an Audit Technician and, in a dual capacity, assisted the Finance and Accounting Officer in carrying out his responsibilities for timekeeping and the maintenance of leave records.

24. On 30 April 1956, Mr. Tobin retired from his position as Chief, Finance Section, having served with the Corps of Engineers for over 41 years.

25. On 1 August 1956, Mr. Moore was promoted from Chief, Cost Section, to Finance and Accounting Officer and Chief, Finance and Accounting Branch, succeeding Mr. Evans who assumed the dual assignment of Chief, Budget Branch, succeeding Mr. Moore. The Budget Branch had been created in that year by direction of OCE, even though part-time, to conform with Corps organization pattern.

26. Reorganization of the Finance and Accounting Branch followed in the fall of 1956, as presently structured, excluding property accounting which remained a

branch until reconstituted a section under the Finance and Accounting Branch in April 1966.

27. As of this reorganization, Mr. Faulkner was appointed Chief, Cost Accounting Section; Charlie A. Randall, Chief, Disbursing Section; Dominic P. Maggio, Chief, Examination Section; and Miss Mary Godley, Chief, Finance Accounting Section. Mr. Randall transferred to the Technical Services Division in August 1959 and was succeeded by James J. Hill, the present incumbent. Miss Godley died 4 May 1960 and was succeeded by Jack C. Garner, the present incumbent. In June 1957, Mr. Martin vacated the position of Chief, Management Branch, by transfer to the Pacific Ocean Division and was succeeded by Billy L. Herrod, the present incumbent.

28. During Fiscal Years 1957-1958, an initial attempt was made to utilize the computer in business application. A system for the collection of labor costs was designed and for a period of approximately four months, parallel procedures were in operation, i.e., both manual and ADP; however, the plan was abandoned on the basis that implementation was not practical because of account classification complexity and computer equipment limitations.

29. In the 1960 fire, the Comptroller organization suffered less operational setback than other organizations that were located in the main building because of regulatory requirements for storing basic accountability records, including the general and subsidiary ledgers and blank checks, in fireproof safes and cabinets.

30. Within the second calendar day after the fire, salvageable equipment and records had been relocated to the Roberts' home just south of the Shops Area; checks were being issued; and other activities were at least operational. Within less than a week, Burroughs Corporation had replaced two Sensimatic Accounting Machines, valued at approximately $25,000, that were less than a year old when lost in the fire.

31. In the next few weeks, while the organization was being reequipped and records salvaged and reestablished, a warehouse in the Shops Area, now occupied by the Supply and Procurement Office, was put in shape for occupancy. This became the location of the Comptroller organization until it was moved to the new Headquarters Building in June 1963.

32. In Fiscal Year 1965, automation efforts were revived. Machine limitations that had forced a deferral of earlier attempts had been by this time overcome. Under guidance of a Programmer--Systems Design Analyst obtained under contract with General Electric, an automated cost reporting system was designed and implemented. The system, utilizing a card configuration, was implemented 1 July 1966 to accumulate on a daily basis cost data such as labor, stock issues, plant usage, and direct charges utilizing source media essentially as were being prepared and required in documentary support to the accounts, with application of indirect charges introduced on a predetermined basis, to prepare a cost status report, machine run, in format essentially as was manually being prepared, but issued on a weekly rather than a

monthly basis, with provisions for special reporting on any job or project within 48 hours on a demand basis. The undertaking, generally regarded as successful, had as its primary objectives: (a) the ability to produce cost and financial data on a more current basis than was possible manually, for managerial needs both locally and by program sponsors; and (b) to strengthen financial management and internal controls by centralizing cost accounting and reporting under Comptroller responsibilities.

33. In Fiscal Year 1966, as a further move by the Chief of Engineers to effect economies in timekeeping and payroll activities, two central payroll offices were established to serve the entire Corps--one in Kansas City, Missouri, and one in Omaha, Nebraska--with Kansas City serving the southern portion of the United States. On 3 April 1966, the Kansas City District began providing payroll services to WES previously provided by the LMVD payroll office in New Orleans. With establishment of the Kansas City Central Payroll Office, leave records were again centralized as a payroll office function, and were converted to automation.

34. On 1 October 1966, at the direction of OCE, WES assumed responsibility for the military accounting and disbursing functions for the Lower Mississippi Valley Division to preclude the necessity for developing the "know-how" and capability in a division whose principal mission involves civil functions only.

35. During Fiscal Year 1967, an ad hoc committee was assigned responsibility, under the chairmanship of William R. Martin of the Office, Technical Programs and Plans, with James F. Smith of the Electronic Computer Branch and Jack Hilderbrand of the Finance and Accounting Branch as members, for the development of a Management Information System--a computerized management system co-designed to eliminate or displace certain manual records (ledgers) in the Cost Accounts, and produce managerial information including manpower utilization, with reporting on an exception basis to measure performance, financial and physical, against predetermined schedules.

36. A systems analyst was again obtained under contract from General Electric to provide guidance in devising a system, developing flow charts, and preparing programs necessary to implement the initial phase on 1 July 1967, with concurrent conversion from a card configuration operation to magnetic tape which had by this time been procured. The system which was placed in operation 1 July 1967 has undergone considerable testing, analyses, and modifications or revisions during the initial months of operation and is being and will be further revised to meet the requirements of management and operating personnel related to the planned phases ultimately embracing physical performance data.

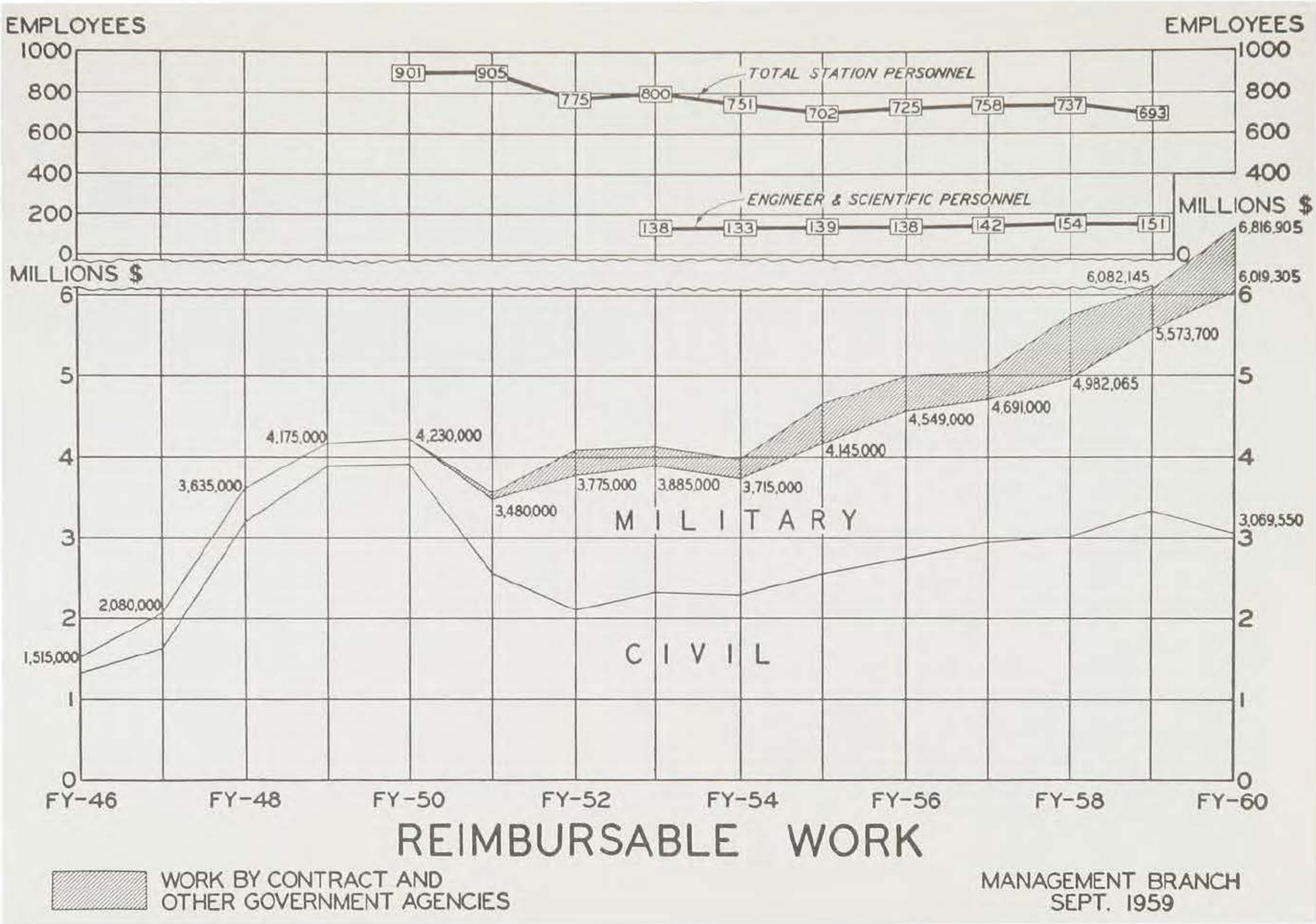
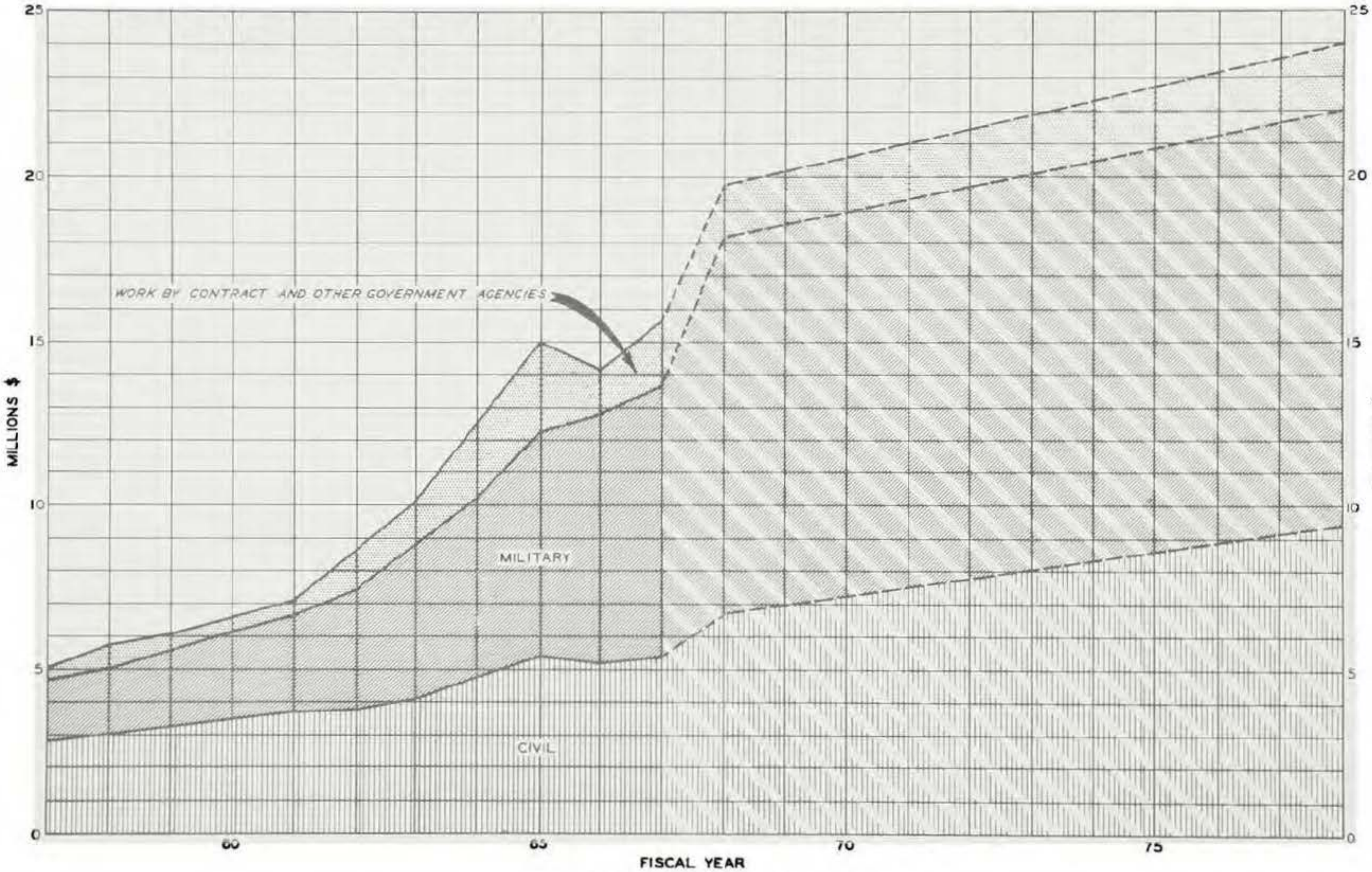

EMPLOYEES
EMPLOYEES
1000
800
600
400
200
0
TOTAL STATION PERSONNEL
901
905
775
800
751
702
725
758
737
693
ENGINEER & SCIENTIFIC PERSONNEL
138
133
139
138
142
154
151
MILLIONS $
MILLIONS $
6
5
4
3
2
1
0
1,515,000
2,080,000
3,635,000
4,175,000
4,230,000
3,480,000
3,775,000
3,885,000
3,715,000
4,145,000
4,549,000
4,691,000
4,982,065
5,573,700
6,082,145
6,816,905
6,019,305
3,069,550
MILITARY
CIVIL
FY-46
FY-48
FY-50
FY-52
FY-54
FY-56
FY-58
FY-60
REIMBURSABLE WORK
WORK BY CONTRACT AND OTHER GOVERNMENT AGENCIES
MANAGEMENT BRANCH
SEPT. 1959

Fig. XVII-1

Fig. XVII-2



REIMBURSABLE WORK
IN-HOUSE AND OTHER

A-2-1

ANNEX A, APPN 2

Appendix XVIII

SAFETY OFFICE

1. Safety functions at WES have been continuous to the degree applicable since the first spadeful of earth was removed from pioneer model studies.

2. Obviously, the many facets of safety operations which are now the order of the day did not apply in the early years. The primary concerns during these days were observing that nails were not left protruding in boards, shovels were placed face down, ditches were shored, etc.

3. C. R. Warndof was the first Safety Engineer, J. B. Tiffany following in 1935, and J. G. Schaffer acting in this capacity from 1936 until 1940. During the period 1940-1945, a succession of employees served as Safety Engineer. All operated in a dual capacity.

4. As the functions of the Station became more diversified, the first Safety Branch was formed in 1946. J. R. Lilly was the Safety Engineer and his office functioned as a branch under the Operations Division, now known as the Construction Services Division. During 1947, the Safety Engineer operated as a staff officer and performed his duties under the direct supervision of the Director of WES. Mr. Lilly transferred in 1948 and J. H. Barnett, Chief of the Plans Branch, assumed his duties in a dual assignment capacity. Mr. Barnett transferred from WES the early part of 1950.

5. On 12 October 1950, J. G. Schaffer operated under a dual assignment as Chief of the Engineering Branch, Construction Services Division, and Chief of the Safety Branch. This assignment was in effect until October 1963. Patrick W. Tompkins assisted Mr. Schaffer as the Radiological Protection Officer. During this period WES twice received the Corps of Engineers Award of Honor for Safety.

6. Again, because of a steady increase in requirements for continuous and full-time safety supervision, the need for an individual to devote full time to this work became apparent. In October 1963, Mr. Schaffer was relieved of his duties as Safety Engineer and E. P. Beacham was appointed as full-time Safety Engineer. Since the Safety Branch functioned as a staff office, it was officially designated Safety Office on 21 October 1963.

7. At a slightly later date, A. E. Mobley was appointed to assist Mr. Beacham. Mr. Mobley is an active member of the Mississippi Chapter, ASSE, and the Federal Safety Council at Jackson, Mississippi.

8. Mr. Beacham transferred to the Post Office Department at Memphis, Tennessee, on 21 April 1967, and A. E. Mobley was designated Acting Chief, Safety Office. Reid Cummins, NWED, was appointed Radiological Protection Officer after the departure of Mr. Beacham.

9. On 28 August 1967, J. W. Pettigrew became Chief of the Safety Office and Radiological Protection Officer. Mr. Pettigrew came to WES from the Little Rock

District and is a registered Professional Engineer in the State of Oklahoma. He is an active member of the Mississippi Chapter, American Society of Safety Engineers, and the Federal Safety Council at Jackson, Mississippi.

10. During November 1963 a WES Safety Committee was appointed to act in an advisory or consultant capacity in the promotion of safety in daily operations. This committee, which meets monthly, is composed of 15 members and is normally chaired by the Deputy Director.

11. The increasing use of radiological materials in connection with WES operations resulted in the creation of the Isotope and Radiological Safety Committee in September 1959 to advise and assist the Safety Engineer on radiation safety.

12. Some of the highlights in safety endeavors have been:

- a. Assisting in the safe recovery of the chlorine barge that sank in the Mississippi River at Baton Rouge, Louisiana, as a result of Hurricane Betsy. The barge sank 10 September 1965 and was raised 12 November 1965.
- b. Extensive modernizing of explosives storage areas at the Jackson and Vicksburg Installations.
- c. The Mono Lake, California, project where 1000-lb cast TNT charges were detonated underwater in 1965-66.
- d. Obtaining an Atomic Energy Commission license for use of radioactive gold 198 in the Houston, Texas, ship channel isotope tracer studies in August-September 1967.
- e. Conducting courses in the National Safety Council's Defensive Driving Program for many WES employees since June 1967.

Appendix XIX

TECHNICAL LIAISON OFFICE

1. The first function in print relating to what is now the Technical Liaison Office appeared in an organization chart dated 29 December 1945 as a Visitors Section under the Administration Division with J. H. Moore as Chief of the Division. The only member shown is Miss Joan Wylie. However, certain public relations functions started when construction of the dam and spillway for the WES lake was begun.

2. Prior to any formal organization, the caring of visitors was the responsibility of professional and subprofessional personnel actually engaged in the model studies. An arrangement was set up which involved an employee calling the telephone operator if a visitor showed up on any part of the grounds. She, in turn, called the head of one of the Experiment Groups who would delegate an employee to show the visitor around the grounds. Depending on his interest, position, technical or nontechnical background, a professional or subprofessional employee would be assigned.

3. Sometime during the late 1930's certain personnel assigned to the Research Center cared for visitors. Three names that come to mind are Charles W. Schweizer, Jr., Maurice Amster, and Frank Morrow. Schweizer entered the Army and retired from the Corps of Engineers within the last few years with the rank of Colonel. Amster, now employed by Ling-Temco-Vought, Inc., of Dallas, visited the Station recently. Morrow also advanced to the rank of Colonel in another branch of the Army and it is believed he is still in the service.

4. With the advent of World War II, WES was closed to most visitors except those coming on official business in connection with work contemplated or in progress. However, during the war years, Mrs. Mary D. "Cecie" King, who worked as a stenographer in the Administration Division, served in some capacity as an aid to official visitors when the occasion arose and prepared drafts of news items to be submitted to the Mississippi River Commission for local release.

5. Following World War II, WES was again opened to visitors and the Visitors Section mentioned earlier, under the temporary charge of Miss Wylie, was reactivated under the Administration Division.

6. By July 1946, the Visitors Section was reconstituted as the Training and Information Branch and was established as a separate organization reporting to the Director. Its functions included training; public information; caring for visitors, including official, foreign, and the general public; hotel accommodations; local travel arrangements; and tours for tourists and school groups and/or special tours for professional or scientific groups.

7. Frank E. Stevenson, who had previously worked in the hydraulics organization, had returned from military service and was designated Chief of the Visitors Section. It then contained two subsections--Information and Training--and while

six spaces were allocated, only four positions were filled.

8. Stevenson accepted a regular commission in the Army and C. H. Lefeve replaced him on 4 September 1946. When Lefeve arrived, there were three employees in the organization; namely, Miss Wylie, who was to return to college in a few weeks; V. Blaine Russell, Jr.; and W. F. Grayson, now Chief of the Administration Section of the Construction Services Division. At that time, the section was responsible for all on-post civilian training. This was in keeping with all training organizations within the Lower Mississippi Valley Division; the training function was not a part of the Personnel organization.

9. By 1 January 1948, the Branch was placed under the Technical Executive Assistant, J. B. Tiffany. Shortly afterward, an RIF necessitated the reduction of one person, and since Grayson was the junior member in years of Civil Service, he transferred to another WES organization. Later, Russell developed arthritis and was forced to move to another climate.* It was then that Mrs. Dorothy H. Laughlin, employed by the Hydraulics Division, and a few weeks later in April, Mrs. Lois C. Meek, employed in the Soils Laboratory of the Soils Division, transferred to the Training and Information Branch.

10. Prior to 1 December 1949, a Technical Services Division, with Mr. Tiffany as Chief, was established and the Training and Information Branch was placed in this Division.

11. Before 1 July 1950, the name of the Branch was changed to Public Relations and Training. Later, the Branch was given the responsibility for the Corps of Engineers central film lending library which was transferred from the WES Research Center Library.

12. Shortly before 15 June 1951, C. B. Patterson, who headed the Research Center, assumed the duties of Chief of the Technical Services Division, and the Public Relations and Training Branch was placed under W. B. Tanner, Chief of the Research Center of this Division.

13. By 1 July 1953, the Public Relations and Training Branch was set up as a separate organization, reporting directly to the Chief of the Technical Services Division, Mr. Patterson. It was about this time that the Branch moved to offices near the main entrance of the new Administration Building.

14. Prior to 1 January 1954, the name of the organization was again changed, this time to the Technical Liaison Branch, and the force consisted of five employees.

15. Shortly afterwards, Mrs. Beatrice B. Hovious joined the staff as receptionist and Mrs. Opal (Powers) Anderson-Smith (presently employed in the Finance and Accounting Branch) was hired as clerk-typist, both having transferred to WES from the Vicksburg District. After a short time Mrs. Hovious transferred to the

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* C. F. Johnson, employed by the Publications Unit of the Reports Branch, transferred to the Training and Information Branch to fill the position vacated by Russell. Johnson later transferred to the Personnel Branch.

to the Reproduction and Reports Branch, and Mrs. Moselle H. Marx assumed the duties of receptionist. Responsibility for the WES slide collection, which had previously been the responsibility of the Research Center Library, was also assigned to the Branch.

16. Shortly before 1 January 1957, the civilian training function was transferred to the Personnel Branch to keep this function in alignment with other Corps of Engineers installations.

17. The WES organization chart dated 1 July 1958, shows elements of the Technical Liaison Branch in two locations. The Branch is shown in the Technical Services Division for certain functions and with the Chief reporting directly to the Director for other responsibilities. This was brought about by a recommendation of the Inspector General during a regular survey of WES. It was believed that such an arrangement would eliminate a channel-of-command bottleneck on certain functions and was in keeping with the organizational pattern of Technical Liaison Offices in other field offices of the Corps.

18. On 30 September 1960, the Technical Liaison Branch was reconstituted as a separate organization on the Advisory and Administrative Staff, reporting to the Executive Office (Mr. Tiffany). Three days later the office was ruined by the "fire" on the morning of 3 October. While some of the office furniture was destroyed, most of the files, slides, and motion picture library were saved except for some water damage. After this catastrophe, the Technical Liaison Branch set up quarters in part of the northeast wing of the original laboratory building at the WES. Mrs. Marx resigned in January 1961 to be married and Mrs. Imyl H. Rice joined the staff as receptionist. She later transferred to the Nuclear Weapons Effects Division and is now head of the Administrative Section of that organization.

19. Shortly after the Mississippi Basin Model (MBM) Board met on 17 July 1962, the visitors program at the MBM was placed under the direct supervision of the Technical Liaison Branch with responsibility for preparation of a comprehensive plan for a self-guided tour of the MBM on a seven-day-a-week basis.

20. On 17 October 1962, the Branch was again placed under the direct supervision of the Director. In June 1963, the Technical Liaison Branch moved into the quarters it now occupies in the Headquarters Building.

21. The Technical Liaison Branch, with the close cooperation of the Director, COL Sutton, organized and conducted a public "Housewarming" during the evening of Friday, 30 August 1963, between the hours of 7:00 and 10:00 to celebrate the formal opening of the new Headquarters Building. After a formal announcement, which appeared in the local and Jackson newspapers on Sunday, 25 August, individual news items about the Station and the celebration appeared intermittently during the remainder of the week. The Station was literally "swamped" with visitors for the event when some 1500 to 2000 people attended. Each person was permitted to inspect the entire new building on a planned and appropriately marked walking tour; was furnished

refreshments in the cafeteria; and viewed exhibits and displays of the WES and other Corps of Engineers offices in the Conference and Class Rooms. This was followed by short, 45-minute conducted tours of the Station's test areas by personnel of the Technical Liaison Branch.

22. The organization chart of 1 February 1964 shows the name of the organization as the Technical Liaison Office, which name it still retains.

23. Members of the present organization include, in addition to Mr. Lefeve and Mrs. Meek, Mrs. Mary S. Hine, who transferred from the Soils Division in May 1955; Mrs. Dale Bean who transferred from the same Division in June 1957; and Mrs. Alma G. Palermo who transferred from the Mobility and Environmental Division in November 1963.

24. From a modest beginning of caring for a few hundred tourist-type visitors a year, the Technical Liaison Office is now responsible for handling all visitors to both the Vicksburg and Jackson Installations of the WES. This includes more than 20,000 visitors who come each year in connection with meetings, conferences, and schools; together with tours for technical, college, and school groups, and regular tours for the general public. Mrs. Lois Meek has been the employee principally responsible for this program for the past twenty years.

25. In addition to all Chiefs of Engineers since 1939, the Station has been host to Mr. Charles Finucane, Under Secretary of the Army, and the following Assistant Secretaries of the Army: Messrs. George H. Roderick, Dewey Short, J. M. Ferry, and Willis M. Hawkins. General Maxwell D. Taylor, former Chief of Staff, U. S. Army, and Chiefs of Engineers from numerous foreign countries have also been guests of the WES.

Appendix XX

WORLD WAR II VETERANS

Jackson H. Ables, Jr.
Fred A. Abraham
William J. Abraham
Clinton A. Adair
Richard G. Ahlvin
Lex Alexander
Henry H. Allen
James V. Allen
John C. Allen
Robert E. Allen
James E. Altman
Robert A. Andress
Donnie E. Andrews
Malcolm Antoine
Guy L. Arbuthnot, Jr.
Guy W. Arender, Jr.
Francis W. Atkinson
William L. Bache, Jr.
Henry J. Baker
Robert B. Ball
Charles L. Barber
John H. Barber
Humphrey Barlow
Howard J. Barnes
James L. Barnes
Sperry E. Bartlett
George H. Bass
Robert L. Batts
Marion D. Beasley
Harris A. Bell, Jr.
William B. Bell
Ralph A. Bendinelli
Robert L. Bennett
Harvey M. Bethea
Bruce N. Bishop
Chester Bishop
Robert E. Black
Claude A. Blackmon
Leon W. Blackmore
Clint N. Blackwell
Manuel Bland, Jr.
Bennie F. Blansett
William H. Bobb
Eloise H. Bodron
Lynwood A. Boell
Brooks E. Boggan
John B. Bogie
Daniel Bolden
Bedford F. Bolin
Vincent Bonelli, Jr.
William L. Boult
George W. Boyd
Horace B. Boyd
Lewis G. Brady
Charles A. Bragg
George H. Bragg
Norman E. Bragg
Charles W. Brasfeild
Earl H. Brasfield
Herman K. Braun
Charlton G. Brent
James T. Brogan
Jim Brogdon
Lamar G. Broome
Alva A. Brothers
A. B. Brown
Alric V. Brown
Ancel O. Brown
Ben Brown, Jr.
Cleopus Brown
Donald N. Brown
Elbert Brown
Henry Brown
Willie Brown
Ralph W. Brumitt
Don R. Bucci
Alan D. Buck
Albert T. Bunn
Marion C. Burgess
Henry Burnett, Jr.
Governor Burns
Harry Burns
James Burns
Samuel B. Burns
Joe L. Burnside
John B. Butler
James A. Byrd
Joseph M. Caldwell
William K. Caldwell
Cecil C. Call
Scott Callahan, Jr.
Melvin M. Carlson
John B. Carothers
Gordon L. Carr
Thomas D. Carraway
John W. Carsley
Edward A. Case
Elbert H. Case
Vincent Cassino
Joe M. Catlett, Jr.
Dave W. Chambers
Emmett Chambers
John B. Chambers
John M. Chappell
Albert Charles
Edward L. Clark, Jr.
Shields E. Clark, Jr.
Walter C. Clark
Sam L. Clay
Henry E. Cloud
Aubrey W. Cockrell
Leonard Coffee
L. A. Coffie
Thomas Coffie, Jr.
Thomas F. Cole, Jr.
Marion T. Coleman
Joseph R. Compton
Clarence J. Connor
Robert R. Connor
David C. Conrad
Jones A. Conrad, Jr.
John A. Conway
David B. Cooksey
Stafford S. Cooper
Edward F. Cotton
Harry Countryman
John W. Countryman
Neill J. Cox
Robert G. Cox
May Sue Craft
David A. Crouse
Albert C. Crowley
Pickney E. Cunningham, Jr.
Robert W. Cunny
Fred Curry, Jr.
Charles L. Daniel
Raymond A. Daumer
Alvis B. Davidson
Charles V. Davidson
Alton G. Davis
Fred D. Davis
Kenny C. Davis
M. L. Davis
Robert Davis
Travis W. Davis
Willie Davis
Joseph V. Dawsey, Jr.
James R. Dennis
Birtnell Denson, Sr.
Joe N. Denson
Henry B. Dent, Jr.
Haywood G. Dewey, Jr.
Fred Dixon, Jr.
George F. Dixon
W. K. Dornbusch, Jr.
George C. Downing
Clyde E. Drake
Leiland M. Duke
Frank J. Durr
John F. Easterby
James F. Elliott, Jr.
Joseph K. Elliott
William Elliott
Thomas Ellis
Adrian D. Ellison
Clarence W. Ellison
Samuel R. Emerson
William J. Emrich
Sterling L. Epps

James B. Eskridge
John M. Evans
Gordon P. Fant
Warren J. Farrell
George B. Fenwick
C. J. Fisher
Edward W. Flowers
Osborn C. Flowers
John A. Focht, Jr.
Joseph A. Forbes
Thomas Forbes
Eugene B. Ford
Norman W. Ford
William B. Ford, Jr.
Albert I. Fortenberry
Eugene P. Fortson, Jr.
Eddie B. Foster
Homer H. Foster, Jr.
James E. Foster
John J. Franco
Joseph L. Franco
Lonnie L. Freeman
Dean R. Freitag
Richard R. Friesz
Zelma B. Fry, Jr.
Charles P. Funches
Albert R. Gann
Jack C. Garner
Robert T. Garner, Jr.
George L. Gaskin
Charles S. Gastrell
Emmett P. Gauthier
Francis B. Gautier
Wallace M. Gay
William W. Geddings, Jr.
Robert M. German
Andrew B. Gibson
Johnnie L. Gibson
Americus M. Gill
Arthur L. Gilmore, Jr.
Dale Glass
Melvin Glass
Ferdinand J. Glassl
Charles Gober
John C. Goodrum
Horace Gordon
Warren E. Grabau
Henry Graves
Wiley F. Grayson
Andrew J. Green, Jr.
Benton H. Green
Eddie Green
Ernest A. Green, Jr.
Harvey H. Green
James M. Green
Trellis W. Green
Homer C. Greer III
Ed L. Griffin
Preston Griffin
Benton W. Groves
Edward E. Guiney
Benson Guyton
Touphie G. Habeeb
Neil R. Hackett
Douglas Halcomb
Milburn R. Hale
Floyd Hall, Jr.
George R. Hall
W. C. Hall
Samuel H. Halper
Clifton M. Hamilton
Harold S. Hanson
John E. Hanson
Julius D. Harbour
William J. Harper, Jr.
James A. Harris
Joe D. Havard
Ernest Hawthorne
Hubert W. Hearn
Walter E. Hembree
James V. Hemphill, Jr.
L. W. Henderson
R. B. Herrington
Billy L. Herrod
Ralph L. Hester
W. J. Hicks
Willie L. Higdon
Clarence C. Higgins
James J. Hill
Jeffrey L. Hill
William A. Hill
Robert E. Hinton
Sandy M. Hodge
John Hoffman
Eugene Hogan
John A. Holliday
Noel W. Hollyfield
Cleveland R. Horne
James L. Horne
Robert C. Hosemann
John G. Housley
Billy J. Houston
Revell Howard
Robert Howard, Jr.
Dowl G. Hoxie
Allen E. Hullum
William C. Hunt
Joseph Hunter
Leo F. Ingram
George P. Ivy
Hal W. Ivy
Robert B. Jacks
David Jackson
Hubert M. Jackson
John G. Jackson, Jr.
Lucius Jackson
Ralph D. Jackson
Robert A. Jackson
Steve J. Jackson
Richard Jacobson
Patrick V. James
Willie James
Major J. Jefferson
George Jetton
Bill Johnson
Charles F. Johnson, Jr.
Glen P. Johnson
Henry E. Johnson
James Johnson
Rufus Johnson
Stanley J. Johnson
Virgil E. Johnson
Walter M. Johnson
William H. Johnson
Clifton D. Jones
John F. Jones
Katharine H. Jones
Roy B. Jones
Walter Jones
Edward Jorden
Alfred H. Joseph
Vivian G. Kaufman
Graves W. Kelly
James A. Kelly
William D. Kelly
I. C. Kemp
Edward R. Kemper
S. Robert Kemper
James G. Kennedy
Curtis A. Kenny
Johnnie B. Kent
Clarence C. Kestenbaum
John H. Kestenbaum, Jr.
Billy R. King
Julius C. King
John H. Klinck, Jr.
Sterling J. Knight
Walter C. Koerper
Charles R. Kolb
John F. Kolb
George R. Kozan
Wyman F. Land
Edgar F. Lane
Francis A. Lanehart, Jr.
James C. Langley
Walter L. Langston
Allan W. Langworthy
Roy M. Lanier, Jr.
James E. Larson
William H. Larson
John H. Lauderdale, Jr.
William F. Lauderdale
N. J. Lavecchia, Jr.
Thomas I. Lawrence
Charles E. Lee
Johnnie E. Lee
R. T. Lee
Tom W. Lee
Willard B. Lee
Grady W. Leese
Glenn Leggett
Thomas A. Leggett
Cornelius Lewis

Jack T. Lewis
Henry O. Lick
Edward L. Liggins
Joseph H. Lindsey
George Love, Jr.
James A. G. Lowe
James A. Lowe, Jr.
Robert M. Lowe
Wilbur I. Luke
Curtis L. Lundstrom, Jr.
Clarence H. Mackey
Thomas J. Magill, Jr.
Louis F. Mahoney
Jacob C. Major, Jr.
Henry E. Markel
James E. Marsalis
Luther C. Marsalis, Jr.
Williiam E. Marsalis
William R. Martin
Emmett C. Maschmeier
Julies Mason
Luther W. Matthews
William D. Matthews
Audley A. Maxwell
Therrel W. McBee
Robert D. McCary
Junius M. McCaskill
George B. McClatchy
Edward H. McCraine
John H. McCray
Harold R. McDonald
Allison McGee
Henry C. McGee
Joseph W. McGee
Thomas W. McGough
Jack H. McInnis
William L. McInnis
Norman McKay
Cody D. McKellar, Jr.
George B. McKinley
Vincent R. McKinley
James A. McLaurin
John A. McLemore
Edmund E. McMaster
James R. McPhearson
John L. McRae
George E. Meaders
James H. Meeks
Louis Meeks, Jr.
Bertrand K. Melton
Edward C. Meyer
Marvin P. Meyer
Alex Miller
Howard L. Miller
William G. Miller
Frank Minder
Emily G. Mitchell
Frank W. Mitchell
James E. Mitchell
Joe M. Mitchell
Alvin E. Mobley

Bob Mobley
Malcolm B. Montgomery
Billy G. Moore
Carter Moore
Louis A. Moore
Wright A. Moore
Edwin E. Moorhead
James Moses
Fred R. Mosley
Harley C. Murphy
James T. Murphy
Thomas E. Murphy
William A. Myers
Joe Nailor
Lodric M. Neal
Everette L. Nelson
Joe Nelson
Donald L. Neumann
John L. Norwood
Nels J. Nyman
Kent A. O'Connor
George E. Olsen
John E. Owens
James P. Pace
William M. Pace
James Palermo
Shelby Palmer, Jr.
Harrell E. Parker
John E. Parrette
Henry T. Parsons
Charles B. Patterson
James R. Paxton
Henry M. Payne
James T. Peatross, Jr.
Benjamin Perkins
Robert Perkins
Jack Perry, Jr.
James Peterson
Julius A. Piazza, Jr.
Vincent J. Piazza
Hossley Pickens
Ellis B. Pickett
Jack E. Pickett
Frederick A. Pieper
Wilbur G. Pittman
James M. Polatty
Malcolm D. Polk
Charlie Powell
Conway Powell
Albert Prentiss
Adelbert W. Price
Edgar R. Price
James Price
Joseph W. Rae
Charlie A. Randall
Eddie Rankins
Milton Ransburg
Joseph T. Ransome
Clarence Rawlings
Hugh K. Reaves
Jesse M. Regan

Paul J. Register
Walter L. Reynolds
Henry J. Rhodes, Jr.
Eddie C. Rhodman
James Richardson
Rudolph E. Richter
John W. Roach, Jr.
Marvin L. Roberson
Ray D. Roberts
Edwin C. Roshore
Sidney R. Rowland
William J. Rowland
Ryland M. Rudd
Sam J. Ruff
Adam A. Rula
Edgar S. Rush
Scott J. Russum
William A. Rutland
William D. Rutland
Edward L. Sadler
William H. Sadler, Jr.
William L. Sadler
Robert Sampler, Jr.
Leonard W. Sanders
Willard Sanders
Kenneth L. Saucier
Esther R. Schabilion
George E. Schabilion
John G. Schaffer
Herman A. Schneider
Edward G. Schroeder
Edward A. Schultz
Marvin B. Schultz
Frank Scott
Johnie C. Scott
Joseph B. Scott, Jr.
George N. Searcy
John H. Shamburger
John M. Shaw
Billy R. Sheppard
Walter C. Sherman, Jr.
Fred D. Shields
Samuel O. Shirley
William H. Simrall
Gordon Sims
Richard C. Sloan
Richard T. Smart
Alfred J. Smith
Henry H. Smith
Hubert R. Smith
Isaac Smith, Jr.
Thomas A. Smith
Ivan L. Sorensen
Paul E. Speake
James M. Speyerer
James D. Spruill
Albert Squire, Sr.
R. T. Stamps
Leo L. Steen
William B. Steinriede, Jr.
Edward Stephens

Charles E. Stevens
Frank E. Stevenson
Booker T. Steward
Frank J. Stewart
Robert Y. Storey
John D. Stouffer
Glenn G. Stout
John N. Strange
Stanley Stratton
Walter Straughter, Jr.
Glynn E. Strickland
Aubrey L. Sullivan, Sr.
Irby C. Tallant
William B. Tanner
Sidney F. Tate, Jr.
Joseph Tatum
Paul L. Tatum
Daniel Taylor
Emmit Taylor, Jr.
Maury S. Taylor
Earl H. Teeter
Thomas E. Templeton
Willie Thomas
Willie C. Thomas
William S. Thompson
Joseph B. Tiffany, Jr.
Clarence L. Tisdale
Fred Toffaleti
James E. Tompkins
Patrick W. Tompkins
John P. Tonnar
Woodie N. Tourne
Henry P. Townsley

Francis E. Trevilion
Burton E. Trimble, Jr.
Robert J. Trussell, Jr.
Sidney G. Tucker
James H. Turner
John W. Turner, Jr.
Lonzie C. Turner
Robert Turner
Wadell S. Turner
Rennie V. Tye, Jr.
William O. Tynes
Philip J. Vedros, Jr.
Louie W. Vernell
Mark A. Vispi
Calvin M. Wade
Kearney Waites
Edith V. Walker
Wilson A. Walker
Ambus Wallace
Ernest S. Walton
Charles R. Warndof
Elias Warner
Henry L. Warnock
Luther Warnock, Jr.
Ervin Warren, Jr.
Elijah Washington
Lyman T. Watson, Jr.
Richard T. Whatley
William W. Whatley
Harry M. Wheeler
George White, Jr.
Percy E. White

Elliott Whitman
Durwood H. Wicker
Joseph B. Wiggins
George A. Wilkerson
Oscar F. Wilks, Jr.
Ester Wilkson
Choicy Williams
Ernest B. Williams
Felix K. Williams
George H. Williams
Harvey L. Williams
Homer T. Williams
Johnnie C. Williams
Nathaniel Williams
Percy O. Williams
Roy L. Williams
Thomas W. Williams
Louie Williamson
Markin Williamson
Howard B. Wilson
Irvin Wilson
James K. Wilson
Maurice G. Wilson
Rufus W. Wilson
Nailor R. Winston
Harry K. Woods
Lloyd Woods
Ray R. Woods, Jr.
Roy H. Woody
Paul Workman
Eulus E. Wright
Roger W. Wright

KOREAN AND/OR VIETNAM VETERANS

William B. Abbott, Jr.
Joseph C. Ables
Fred A. Abraham
Louis Adams, Sr.
Eugene E. Addor
Donnie L. Ainsworth
Samuel J. Alford
Ernest F. Allen
Henry H. Allen
Robert J. Alvarado
George L. Anderson
Henry R. Anderson
Ronald K. Anglin
William L. Bache, Jr.
James T. Ballard
Jose E. Ballesteros
Larry A. Barnes
Sperry E. Bartlett
Erwin A. Baylot, Sr.
Benjamin E. Beard
John W. Beasley
Ralph A. Bendinelli
Bob O. Benn
Joseph D. Bennett
Billy W. Benson
Danny P. Biggs
John A. Boa, Jr.
Robert A. Boland, Jr.
Anthony A. Bombich
William C. Boutwell, Jr.
William N. Brabston
George H. Bragg
Charles W. Brasfeild
Earl H. Brasfield
August J. Breithaupt
Jerald D. Broughton
Ancel O. Brown
Billy R. Brown
Gerald F. Brown
Herman R. Brown
James B. Brown
Lawrence Brown
Don R. Bucci
Floyd R. Bufkin
Donald G. Burkell
Henry Burnett, Jr.
Samuel B. Burns
James W. Carr
Gary L. Carre
Louis D. Carter
James B. Cheek, Jr.
Ralph Chiti
Leo Colenburg
John B. Collins
Neill J. Cox
Albert C. Crowley
Moody M. Culpepper
Reid S. Cummins, Jr.
Robert W. Cunny
Donnie S. Daniels
Raymond A. Daumer
Billy R. Davis
Joseph L. Decell
Curtis L. Dent
Charles W. Denzel
A. Paul Desmarais
Haywood G. Dewey, Jr.
Phillip L. Doiron
Frank W. Dorsey
Donald H. Douglas
Gary N. Durham
Gerald T. Easley
John F. Easterby
Royce C. Eaves
Joseph K. Elliott
George Ellis
Mose Ellis
Dave A. Ellison
John M. Evans
James O. Farrell
Warren J. Farrell
Vernon C. Farrior
William J. Flathau
Arthur R. Fleetwood
John A. Focht, Jr.
William B. Ford, Jr.
Eugene P. Fortson, Jr.
John J. Franco
Norris A. French
Lonnie R. Friar
Edward A. Frost
John L. Gargaro
James E. Gilbert, Jr.
James E. Glover
Horace Gordon
Jerry A. Graham
Trellis W. Green
Willie Green
Paul F. Hadala
George M. Hammitt II
Roy H. Harmon, Jr.
Reginald G. Harris
Ellis D. Hart
Colon E. Hartley
Lyman W. Heller
Billy T. Helmuth
James V. Hemphill, Jr.
Frank A. Herrmann, Jr.
Billy L. Herrod
Jack Hilderbrand
George C. Hoff
Kenneth W. Holaway
Robert Howard, Jr.
Melvin J. Hubbard
William C. Hunt
Carl J. Huval
Emery L. Irwin
Hal W. Ivy
Sherman Jackson
Joseph J. Jenkins
George Jetton
Charles E. Joachim
Charles F. Johnson, Jr.
Robert R. Johnson
Virgil E. Johnson
Charles Jones, Sr.
Philip H. Jones
Billy R. King
John J. Kirschenbaum, Jr.
John T. Kitchens
Edward M. Landers
Edgar F. Lane
James C. Langley
William H. Larson
William F. Lauderdale
Kenneth G. Lawrence
Johnnie E. Lee
Tommie Lee, Jr.
Donald B. Leggett
Hardy Lewis, Jr.
Jerry L. Lundien
Curtis L. Lundstrom, Jr.
Richard J. Lutton
Bruce N. MacIver
Henry E. Markel
Luther C. Marsalis, Jr.
William E. Marsalis
William R. Martin
Audley A. Maxwell
John R. May
James Mayfield, Jr.
Robert D. McCarley
James V. McGuffie, Jr.
George E. Meaders
Edwin S. Melsheimer
Alvin E. Mobley
Bob Mobley
Harrell D. Molthan
Eddie Lee Moore
Thomas E. Murphy
Lewis B. Naron
Lodric M. Neal
John L. Norwood
Kent A. O'Connor
Elzie O'Neal
Billy W. Pagan
Shelby R. Palmer
Floyd C. Patrick
James W. Pettigrew

Julius A. Piazza, Jr.
Vincent J. Piazza
James L. Pickens
Frederick A. Pieper
Harley C. Pierce
John M. Pinkston, Jr.
Jack K. Poplin
Conway Powell
Sherman B. Price
Donald D. Randolph
David Reed
Donald Reed
Louis R. Renaud, Jr.
Albert G. Reno
James Richardson
Robert E. Riley, Jr.
John W. Roach, Jr.
Lloyd W. Rogan
Thomas B. Rosser III
Scott J. Russum
William H. Sadler, Jr.
Richard A. Sager
David A. Saunders
Milford D. Saxon

Marvin B. Schultz
George N. Searcy
John H. Shamburger
Louis J. Shows
Pat A. Shows
William H. Simrall
Frederick L. Smith
Henry H. Smith
James F. Smith
Jerry L. Smith
Perry A. Smith
Robert P. Smith
Stephen J. Snyder, Jr.
Alston C. Spivey, Jr.
James Stabler
John S. Stallings
Edward Stephens
Richard L. Stowe
Walter Straughter, Jr.
William E. Strohm, Jr.
Thomas E. Stukes, Jr.
Albert L. Sullivan, Jr.
Albert L. Sullivan III

Aubrey L. Sullivan, Sr.
Gerald G. Switzer
Johnny S. Taylor, Jr.
Henry T. Thornton, Jr.
William L. Thornton
Patrick W. Tompkins
Charles C. Trahan
Burton E. Trimble, Jr.
Robert J. Trussell, Jr.
Harry H. Ulery, Jr.
Timothy W. Vollor
James R. Wainwright
Donald M. Walley
Buel F. Warden III
Burl E. Warnock
Luther Warnock, Jr.
Vernon M. Welch, Jr.
Ardell Williams
John S. Williams
Thomas P. Williams
James K. Wilson
Ronald T. Wooley
Benjamin F. Wright

Appendix XXII
FIRE OF 3 OCTOBER 1960

1. The following account of the early morning fire of 3 October 1960 was prepared by Mr. J. B. Tiffany on 20 October 1960 for the purpose of informing friends and sponsors of work at the WES of the fire that practically destroyed the Administration Building. Since word of the fire had already been spread widely and since incorrect rumors had arisen as to its cause, the extent of the loss, and its significance to WES operations, it was considered desirable to prepare and disseminate a brief account of what occurred, the extent of the loss, the rehabilitation measures taken or to be taken, and plans for the replacement of the lost facilities.

2. A Board of Investigation appointed by the Director while the fire was still burning had concluded, among other findings: (a) that the exact specific cause of the fire could not be positively determined; (b) that the fire was probably of electrical origin, the most likely cause being either the malfunctioning of the ballast in a fluorescent lighting fixture or the development of a short circuit in electrical wiring; and (c) that there was no evidence or indication of any faulty workmanship or materials in the building or its electrical system. This Board was composed of: Messers. G. B. Fenwick, Chairman; W. G. Shockley; W. B. Tanner; J. J. Kirschenbaum, Recorder; and CPT J. E. Wagner.

3. The building which was destroyed included the front or main wing of the Administration Building, and the three wings perpendicular to the front wing. In the building destroyed were located the following: the Executive Offices, the Personnel Branch, Main Conference Room, the Comptroller Staff except the Property Branch, the Office Service Branch, the Print Shop, the Photography Laboratory, the Drafting Room, all the offices occupied by the Reports Section, the Research Center and Library, the Technical Liaison Branch, the Computer Center, and the Cafeteria.

4. In further detail, the following were lost: the IBM 650 Computer, valued at about $400,000, and owned by the IBM Company; all the printing presses and appurtenant equipment in the Print Shop; all of the Photography Laboratory equipment such as dark rooms, development sinks, printers, etc., including several cameras and other equipment; the entire technical library collection including over 75,000 items, plus the card index of 275,000 reference cards, published indexes, bibliographies, translations, etc.; practically all of the Mail and Records Section's current files of unclassified correspondence; some of the files of the Personnel Branch and Finance and Accounting Branch (see below); a large number of reports being edited and prepared by the Reports Section; all of the equipment in the cafeteria (most of it privately owned); and practically all of the desks, furniture, typewriters, and other equipment in the building. Fortunately, most classified material was in fireproof containers and was recovered. Practically all of the basic "201" files of the Personnel Branch and the most important records of the Finance

and Accounting Branch were saved from loss by special attention given during the fire-fighting operation, when hoses were directed on the cabinets containing those records when it became apparent that the building itself could not be saved. A few other items of equipment, reports, etc., were salvaged from the fire.

5. The total dollar value of the loss incurred, including the building itself, the equipment, the IBM Computer, the Library contents, etc., was tentatively estimated at approximately $1,400,000. In addition, the cost of replacing the burned reports which were being edited, the cost of emergency construction after the fire, moving of offices, etc., probably brought the total dollar loss to about $1,700,000. The replacement cost was even greater since prices had risen appreciably since the building was constructed, as had prices of equipment. A monetary value could not be placed on the valuable technical data and records destroyed by the fire, some of which could not be replaced.

6. Before the fire in the building was extinguished, the Director not only appointed a Board to investigate the cause of the fire and make the necessary reports to higher authority, but appointed another group to devise means for continuing operations and to make an immediate survey of space available elsewhere at the Vicksburg Installation and in the city of Vicksburg itself. By Wednesday, 5 October, space had been found for housing all of the 140 employees who had worked in the building that was burned, and the actual moving of units of the organization was started even on the morning that the fire occurred. As of the date this report was prepared, all units of the WES had been adequately housed, and practically all parts of the organization had secured replacement equipment required to place them in full operation. Some of the detailed moves which were made are listed in the following paragraph.

7. The Executive Offices were moved on the morning of 3 October to the building formerly occupied by the Construction Services Division; most of the units of the Personnel Branch and Office Service Branch were also moved into that building. The Construction Services headquarters was moved to a building northeast of Hangar 2, formerly occupied by a unit of the Forestry Service; the Forestry Service people were moved temporarily to a new building which was nearly completed for the purpose of housing the Terrain Analyzer Section of the Soils Division. The Comptroller organization was moved temporarily to a private home adjacent to the WES reservation, and a week later was moved to a warehouse building on the reservation, just north of the Supply Branch, which was rebuilt and finished inside for their occupancy. The Technical Liaison Office was relocated on the first floor of the west wing of the Soils Division building. All of the units of the Technical Services Division that were burned out, except the Computer Center, were reestablished in a three-story wing of the building occupied by the Vicksburg National Military Park headquarters, in space formerly occupied by the Mississippi River Commission and the Vicksburg District. The Computer Center was relocated in the basement of the Peeples-Newman building in downtown Vicksburg, in part of the space normally occupied by the Vicksburg District's

Soils Laboratory. All of the IBM 650 equipment necessary to get the Computer back into operation was actually installed and in full operation on Thursday, 13 October, only 10 days after the fire. This represented a record accomplishment not only for the WES but for the IBM organization. The Print Shop was back in business almost immediately with a 1250 Multilith, and in less than a month was back in almost normal operation in Army vans containing printing presses, copy cameras, etc., which were obtained on an emergency loan basis from the Engineer Research and Development Laboratories at Fort Belvoir, Virginia. Plans were made within a week or so for construction of temporary facilities for the Photography Laboratory in a part of the Administration Building that was not completely destroyed.

8. The Planning and Development Committee of the WES was assigned, on 3 October while the fire was still burning, the task of making plans for the construction of a building or buildings to replace the Administration Building. Space estimates were completed, a preliminary cost estimate was prepared, and a teletype sent to the Office, Chief of Engineers, for funds and authority for construction of two new buildings, plus supplemental space for certain units of the Soils Division which were considered to be inadequately and even dangerously housed. Sites for these buildings were tentatively selected, contacts were made with several architect-engineer firms, and a Board appointed to recommend the selection of an architect-engineer firm to prepare construction drawings for the replacement buildings within two weeks after the fire. It was estimated that about three months would be required for the preparation of plans and about one year for construction of the proposed new buildings. Of course, plans for the buildings proposed and funds therefor had to be approved by the Office, Chief of Engineers, and it could not be determined at that time how much of the proposed program would meet with approval. It was proposed to build the new building to house the Administrative groups and the Technical Services Division on a new site on higher ground, not in the area occupied by the building that was burned.

9. Owing largely to the perception and vigorous action of those engaged in fighting the fire, the fire was kept from spreading to the two Soils Division wings and Soils Laboratory, which constitute the original WES building. Except for some minor and temporary water damage, only one of the Soils Division offices was damaged. The Hydraulics Division and Concrete Division were not affected by the fire in any way except for the minor inconvenience of the loss of certain reports, correspondence, and other files contained in the Administration Building.

10. Thus, we were glad to be able to report that the technical capabilities of the WES, except for a temporary interruption of our library service, were not impaired in any way because of the fire loss.

11. The Architect-Engineer Selection Committee appointed by the Director consisted of Messrs. J. B. Tiffany, Chairman, E. P. Fortson, G. W. Vinzant, and E. H. Teeter. This committee was assigned the mission of examining the qualifications of all of the architect-engineer firms indicating an interest in the proposed contract

to perform the architectural work and supervision of construction in connection with the reconstruction program. This same committee, supplemented by Mr. W. L. Bache, Executive Assistant, served as the negotiation team for the architect-engineer contract. Negotiations were begun with the R. W. Naef Company, Jackson, Mississippi, on 22 November 1960 and a contract was signed with that firm on 15 December. The contract for construction of the building was awarded to Sarullo Construction Company, Greenville, Mississippi, in the amount of $805,000 on 25 October 1961. The new headquarters building was occupied in June 1963, and on 30 August 1963 Open House was held at the Vicksburg Installation to show facilities and work operations to the friends and families of employees and to the citizens of Vicksburg.

Appendix XXIII

1953 TORNADO

Foreword

1. A tornado formed on the Louisiana side of the Mississippi River, southwest of Vicksburg, at approximately 5:35 p.m. on Saturday, 5 December 1953, and traveled in a generally northeasterly direction. It first hit in the southwestern part of Vicksburg and followed a north by slightly northeast path through the city. Damage was limited to the industrial, business, and residential areas lying in the western half of Vicksburg, adjacent to the Yazoo Diversion Canal and extending approximately 2000 ft east of the Canal.

Rescue Activities

2. COL Carroll H. Dunn, Director of the WES, was advised of the disaster at 6:15 p.m. on 5 December 1953. The WES was not in the path of the tornado and suffered no damage. COL Dunn therefore proceeded immediately to the disaster area in downtown Vicksburg, after alerting security forces at the Station and directing that J. G. Schaffer, Chief of the Construction Services Engineering Branch, be contacted and requested to report to the Station.

3. Upon arrival downtown, the Director made a hasty reconnaissance of the area and then contacted Pat Kelly, Mayor of Vicksburg, to offer the Station's assistance. Mayor Kelly accepted this offer and requested COL Dunn to do whatever rescue work that, in his opinion, was needed and could be accomplished by Station forces. COL Dunn contacted the WES and issued instructions for the mobilization of emergency forces and equipment. Guards on duty at the Station immediately contacted Construction Services Division personnel and requested them to report to the Station.

4. Shortly after 6:30 p.m., three portable lighting units (two 15 kva and one 5 kva) with attendant floodlights, cable, etc., and one of the Station fire trucks and a fire-fighting crew were dispatched to the stricken area. Part of the emergency personnel force which had, in the meantime, reported to the Station was sent with the equipment to set it up and operate it. The remainder of this emergency force commenced servicing and making ready for use numerous items of construction equipment that it was foreseen would be required. By 8:30 p.m., lighting units had been set up and were operating at the Saenger Theater and at the corner of Walnut and Clay Streets. Floodlights had also been connected to some other unit's generator to provide illumination for rescue workers in the vicinity of the First National Bank and Palermo's Clothing Store on Washington Street.

5. The Station's fire truck, a 500 gpm pumper, and crew were sent to the Central Fire Station, as all city fire equipment had been committed. This truck made

two runs during the night to assist in fighting fires in the vicinity of the Sears Roebuck warehouse and the Federal Compress warehouse and remained in a standby status at the Central Station during the time it was not so engaged.

6. At about 8:30 p.m., CPT Carroll N. LeTellier and LT William L. Durham joined the Director, who had decided to establish a Command Post (CP) in the office of the Southern Bell Telephone Company on Crawford and Monroe Streets. CPT LeTellier and LT Durham alternately manned this CP throughout the night and directed operations of WES forces and equipment from that location. J. B. Tiffany, Assistant Director, relieved CPT LeTellier at the CP early on the morning of 6 December. Significant operations conducted by WES personnel during the night were:

a. A survey was made of power requirements of all hospitals in order that emergency service could be supplied in the event of power failure. At the request of Dr. Walter Johnston, the lighting unit in use at the corner of Walnut and Clay Streets was sent to Charity Hospital, after a power failure in the hospital. However, service was restored before the unit could be put into operation.

b. The third WES portable lighting unit was set up and operated at the YMCA for the Mississippi National Guard forces headquarters.

c. The lighting unit that had been sent earlier to Charity Hospital was set up and operated at the corner of Crawford and Mulberry Streets to aid rescue operations at that point.

d. A pumping unit was set up in the basement of the Hotel Vicksburg to remove water that had flooded the basement.

e. Periodic checks of all equipment in use were made throughout the night and Station employees worked continuously with other volunteer forces to rescue persons trapped in collapsed buildings and to recover bodies of victims.

7. At approximately 6:00 a.m. on Sunday, numerous items of construction equipment, operated by Station personnel, were dispatched from the WES. Besides being used to clear Washington Street from Clay to South Streets of all debris, this equipment was used wherever needed in cleanup activities at various locations in the downtown area until assignment to the Station of a specific area of responsibility at about 9:00 a.m.

8. At 7:45 a.m. (Sunday, 6 December), the Director sent the following teletype message to the Chief of Engineers:

> Reference telephone conversation from General Hardin to Office, Chief of Engineers, 5 December, no damage to Waterways Experiment Station property or personnel. Damage to private property in city, center and northeast section, extensive. Overall casualty figures as of 0700, 6 December, 18 dead, over 300 injured. Coordinating with General Hardin in rendering all possible assistance for disaster relief. Power out in Mississippi River Commission and Vicksburg District offices. Messages for those offices, as well as Waterways Experiment Station, should be routed to Waterways Experiment Station. WES station will operate on 24-hour basis until further notice.

9. The Director attended a meeting of City officials, Army representatives, and representatives of relief agencies, in the City Hall at 8:00 a.m. on 6 December, at which time Federal aid was officially requested by Pat Kelly, Mayor of Vicksburg. The Corps of Engineers agencies in Vicksburg were specifically assigned responsibility for relief activities. By this time, survivors who had been trapped in collapsed buildings had been rescued. The major job remaining to be done was, generally, the removal of wreckage and recovery of bodies of victims.

10. Throughout Sunday, 6 December, Station forces and equipment were engaged in the recovery of bodies of victims; shoring of certain buildings to prevent further collapse; removal of overhanging debris, such as dangling wires, tin, wood, etc., from poles and buildings; pulling down badly damaged, unsafe walls (after clearance therefor had been obtained from City officials); clearing all streets in the assigned area of rubble and wreckage; and providing equipment, material, and services to other relief forces upon request. By about 5:00 p.m., all bodies had been recovered from the Saenger Theater and all emergency work at that site was completed. City officials were so informed.

11. Cleanup operations were discontinued at about 5:30 p.m. on 6 December and commenced again at 6:30 a.m. on the following morning (Monday). However, throughout the night, duty officers were maintained at the CP and at the WES to handle emergency calls and requests. The Station's warehouse was kept open and personnel of the Equipment Section were alerted for call during the night, if necessary. Several requests for assistance of a minor nature were handled by duty officers and warehouse personnel during the night.

12. By 11:30 a.m. on Monday, 7 December, WES forces had completed their assignment. The area was jointly inspected at this time by COL T. B. Simpson, District Engineer, Otto Finane, Vicksburg Chief of Police, Mr. Tiffany, and Charles R. Warndof, and it was found that the Station's mission had been accomplished. The area was therefore cleared at this time and Station forces and equipment returned to the WES.

13. In accomplishing its mission, the WES had removed approximately 625 truckloads of debris from its area of responsibility and disposed of this debris at a designated dump on the Yazoo Canal, south of the Vicksburg District Shops. Close coordination had been necessary between the Station's field forces under Mr. Warndof, Mr. Tiffany and his assistants at the CP, and support forces under W. L. Bache, Jr., at the WES. Coordination was also necessary between Station forces and the headquarters of the Vicksburg District and other relief agencies, as the District supplied labor for the WES area from volunteer labor pools, and private concerns such as the Mississippi Power & Light Company supplied certain items of equipment used in the area. This essential coordination was accomplished, and by the combined

efforts of all concerned, crews were organized and shifted as the need arose and were kept supplied with material and equipment needed in their operations.

Personnel

14. Approximately 400 male Station employees assisted in rescue and cleanup operations. In addition, 32 female employees assisted various relief and religious organizations in providing food, clothing, nursing services, etc. This total of 432 Station employees worked approximately 5000 man-hours during the period from 6:00 p.m. on 5 December to noon on 7 December. The greatest concentration of labor occurred during the period from 8:00 to 5:30 on 6 December. The time worked by Station personnel on 5 and 6 December was on an entirely voluntary basis; these employees later declined payment for their efforts.

15. In addition to the above, a total of seven Station employees served with the Mississippi National Guard on patrol and police activities in the disaster area.

16. WES employees working in the Station's area of responsibility were assisted by an estimated total of 450 volunteer workers, with the voluntary forces present at any given time ranging from 50 to 150 workers.

Materials and Equipment

17. The WES provided equipment, material, and supplies for use of its own forces and those of other agencies engaged in rescue and cleanup activities.

Communications

18. Local telephone communications were completely disrupted by the tornado. These facilities were partially restored within a short period, but the limited service was not adequate to handle the heavy load which naturally followed the disaster. Personal messenger service was extensively utilized for local messages and limited long distance service was available for official communications.

19. Teletype circuits at the WES were unaffected by the tornado, but the circuits serving the Office of the President, Mississippi River Commission, and the Vicksburg District were disrupted temporarily. The Station therefore provided teletype services for all three Engineer agencies in Vicksburg and also handled emergency messages for the American Red Cross until the morning of 8 December, when the other circuits were fully restored. Twenty-four hour teletype service was maintained during this entire period.

Funds

20. WES operations in connection with the tornado disaster cost approximately

$3950. This total is broken down as follows:

Labor		$3080
Materials and supplies		245
Repairs to equipment		625
	Total	$3950

The cost of labor reported above represents work performed on Monday, 7 December, and a minor amount of carry-over work on 8 December. Employees who were contacted by name through the Station and requested to report for work on Saturday and Sunday, 5 and 6 December, were, under existing regulations, entitled to overtime compensation for the services they rendered on those dates. However, as previously stated, all concerned considered their services as part of the community effort and declined payment.

AN EDITORIAL FROM THE VICKSBURG EVENING POST
OF DECEMBER 9, 1953

Order Out of Chaos

In Vicksburg, as always happens when a major disaster strikes, a condition of chaos and confusion immediately developed, particularly when the extent of the damage began to be realized. And in such confusion it is imperative that order be restored as quickly as possible. Immediately after the tornado struck Saturday night, hundreds dove into rescue work, but direction and coordinated action were necessarily lacking. To the everlasting credit of Mayor Pat Kelly and the Board of Aldermen, Vicksburg early Sunday morning began to bring order out of chaos. The National Guard and the Reserves were called out for the very necessary job of patrolling and preserving law and order. They responded with efficiency characteristic of our great army. Legionnaires and members of the VFW became quickly organized and were made available for all kinds of duty. A master stroke was made when the entire disaster area was put in charge of the Corps of Engineers.

Vicksburg has always been exceedingly loyal and staunch in support of our Army Engineers. Down through the years we have observed the wonderful work of the Corps in their continuing and successful efforts toward control of the mighty Mississippi. Engineering brains and know-how are more in abundance in Vicksburg than in any place we know. They worked for Vicksburg, beginning Sunday morning and under the magnificent direction and organization of the U. S. Engineers, streets were cleared, debris moved, danger areas spotted and restricted. The work was so systematically performed and so swiftly executed as to be almost unbelievable. With command and outpost stations functioning as in wartime, under the direction of General John Hardin, of the Mississippi River Commission, and under the personal supervision of Colonel Thomas B. Simpson of the District Office, with Colonel Carroll H. Dunn of the Experiment Station assisting, the Engineers did an amazing job. Bulldozers and scrapers and dump trucks were incessantly on the move and the hundreds of wonderful volunteer workers kept them at high speed.

The work of the Engineers, every one of them and their trained personnel and their volunteer helpers, will remain indelibly inscribed on the pages of Vicksburg's history. In our saddest hour, the Corps of Engineers did more than anyone else to bring order out of chaotic Vicksburg. We proudly salute them.